POWER

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Hanging onto Prosperity

THE principle threat to the continuance of prosperity is that it is taken in too large doses.

To too many men prosperity means fifty per cent profits on maximum capacity.

They are not content to take a fair profit on normal production and do not think they are busy unless they are running nights.

Labor, although resenting being classed as a commodity, is particularly sensitive to the influences of supply and demand. It asserts its claim for a share of the golden harvest and, as the going is too good to be stopped, its demands are acceded to.

And the ultimate consumer is paying $16 a day plus a contractor's profit for labor that requires no greater mental capacity or physical exertion than pasting together the limited number of bricks that the union allows for a day's work.

There is no physical reason why there should not be a long period of business activity before us if people would be contented with activity and not insist upon frenzy.

A large proportion of our people are at work at good wages. They are in a position to buy.

The shelves and storehouses of the world, although not empty, are not over-full. There are no large stocks ahead except perhaps in a few lines.

As a result of the war activities we are over-equipped for producing our necessities. If all the war babies were put to work at full capacity, they would soon flood the market.

People do not have to buy. There are many things that they can get along without. Sixteen-dollar-a-day bricklaying and other concomitant extortions have sidetracked millions of dollars' worth of building contracts. Perhaps the "market" is getting wise and will not "bear" as much as it used to.

The striker for big wages and short hours is striking, not against his employer, but against all other laborers. His employer will simply pass the increased wage along (with more or less of a bonus) to the other laborers who are the consumers of the products of the successful strikers.

It is a simple lesson but hard to learn, that big wages do not make prosperity if they will not buy any more, and that the way to keep up a good healthy demand which will keep the mills running and the people able to buy is to keep the price of things down.

Give a good day's work for a fair day's pay, practice the efficiency and avoidance of waste that will reduce the cost of production, and then watch the profit takers all along the line.

Extortion is not a prison offense yet, but some of the extortionists are beginning to feel uneasy.

MUNICIPAL POWER PLANT

Lansing, Michigan

by O.E. Bulkeley*

PLANT operated by Board of Commissioners. Initial installation 25,000 kw. Steam supplied to turbines at 275 lb. pressure and 200 deg. superheat. Six 15,000-sq. ft. V-type boilers, each fired by sixteen retort underfeed stokers. Forced draft supplied by independent motor-driven fans. Centralized boiler control system. Heat balance maintained by house turbines and steam extraction. Evaporators supplied for distillation of feed-water makeup. All steam and other headers located below operating floor. Plant designed for maximum accessibility and daylight illumination.

LANSING differs from many State Capitals in that it is an important industrial city, growing and developing at a phenomenal rate. As evidence of this the consumption of electric energy during the winter of 1922-23 increased 60 per cent over the previous winter.

The utility business conducted by the Board of Water and Electric Light Commissioners operates under a broad charter and embraces the supply of water for all purposes, including industrial uses within the City of Lansing, the supply of steam heat for the business section and the supply of light and power for all purposes in Lansing, East Lansing and the territory immediately surrounding these two cities. The industrial plants obtain all their power from the city plants.

It is not necessary or even advisable in this paper to present historical facts regarding the inception of the business. It should, however, be stated that in September, 1919, the city took over the plant of a competing company in order that the industries of the city should not be closed down for want of power, as this company was at that time in the hands of a receiver. An equitable basis for purchase had already been established.

*Superintendent, Board of Water and Elec. Light Commissioners.

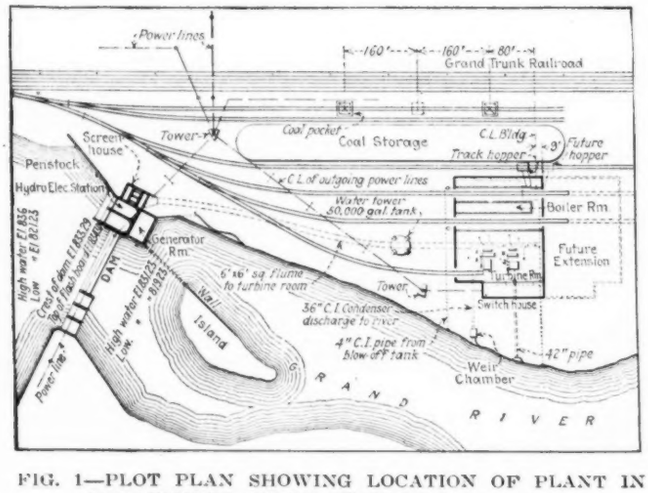


FIG. 1—PLOT PLAN SHOWING LOCATION OF PLANT IN RELATION TO CIRCULATING WATER SUPPLY AND RAILROAD FACILITIES

During the winter that followed, the rapid growth of the city forced to an issue the problem of how to obtain greater generating capacity. Owing to this new acquisition, the Board was then operating two steam plants and one small hydro-electric station. Further development of either steam station appeared to be impractical, if not impossible. It was realized that the engineering problem involved was somewhat complicated and that the preliminary engineering would entail comprehensive study because of the fact that three plants were already in existence, operating at different voltages, with inadequate tie lines and distribution system duplicated in many parts and seriously overloaded in other parts. Engineers were finally selected to make complete appraisal of all electrical properties and prepare preliminary plans for a new power station of not less than 40,000 kw. ultimate capacity. Many obstacles had to be met and overcome in order to finance the project. But when the way finally opened, bonds to the extent of $1,650,000 were voted on Aug. 30, 1921, after which the engineers were authorized to proceed with the preparation of construction plans. Bids on all principal items were taken Jan. 11, 1922, and actual construction of the building began Feb. 22, 1922.

The present valuation of the electrical properties is $3,098,543.58, which will be increased to approximately $6,000,000 by the construction of this new plant, known as the Moores Park Station.

The site donated to the city by the Olds Motor Works for the new power station is more favorable than any other in the vicinity of Lansing. The area, nine acres, is sufficient for future additions to the plant and the location, on the Grand River, below the dam of the hydro station, insures an ample supply of cooling water under nearly gravity flow for the condenser, up to a capacity of 55,000 kw. The storage above the dam will provide a working reserve of water supply for ten to fifteen days in periods of low water.

Open yard storage for 20,000 tons of coal is provided by track sidings from the Grand Trunk Railroad, and this storage capacity may readily be increased by added trackage.

It was decided to design the plant on a unit plan with an ultimate capacity of 40,000 to 55,000 kw. The first unit, which is now practically finished, consists of one 10,000-kw. unit with three boilers and one-half of the ultimate building structure. The second unit of 15,000 kw. and remaining three boilers will be installed the present year, thus completing one-half of the ultimate plant and affording a generating capacity of 25,000 kilowatts.

The building is of brick and steel with concrete footings under each column carried down to bedrock. Cornice and band courses are of terra cotta of a color to harmonize or blend with the color of the brick exterior walls. The base course at grade is of natural granite with cast stone of the same color and texture above the finish of the base of the building up to the first story windows.

The building is approximately 205 ft. wide and 154 ft. long divided into three sections, boiler room 107 ft. wide, turbine room 70 ft. and switch bay 28 ft. wide by 108 ft. long, five stories in height.

The walls of the turbine room and switchhouse are faced with salt-glazed brick of buff color, and the floor of the operating gallery in the turbine room is of Welsh quarry tile.

Plant Designed for Maximum Daylight Illumination

Special study was given to daylight illumination in the boiler and turbine rooms, and the maximum admission of daylight was secured through skylights aggregating 14,000 sq.ft. and through ample window area located in the most effective positions.

Two radial-brick chimneys 13 ft. in diameter at the top are built on the structural supports and framework of the building. Each chimney is 200 ft. high and the bottom or base starts from a concrete-encased girder platform 80 ft. above grade, or 57 ft. above the boiler floor, affording an effective stack height 250 ft. above the grates.

Condensing or cooling water flows directly from the river through a rectangular concrete flume of 42 sq.ft.

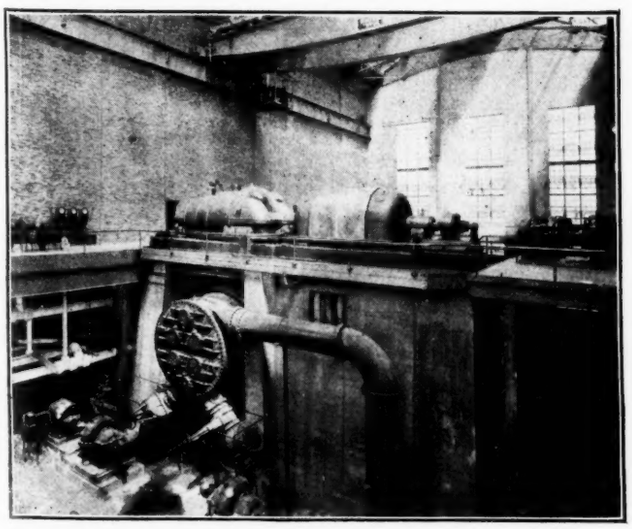


FIG. 2—TURBINE ROOM SHOWING 10,000-KW. UNIT AND CONDENSING EQUIPMENT

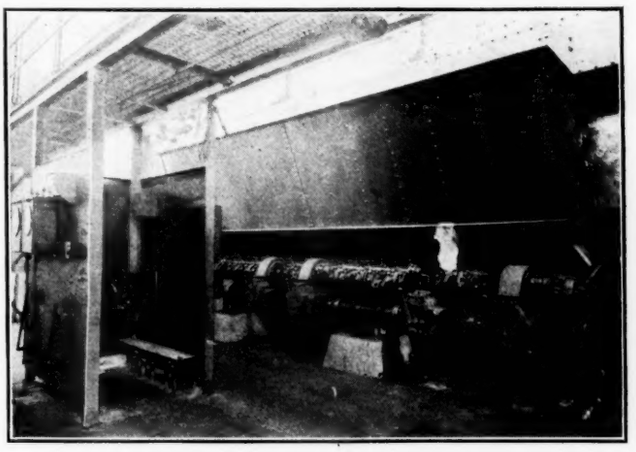


FIG. 3—VIEW OF SIXTEEN-RETORT AND BOILER-CONTROL PANELS

cross-section under ground from the screenhouse, which is built alongside of the penstock of the present hydro station, located about 500 ft. from the plant as shown on the plot plan. The flume is designed to serve the ultimate capacity of 55,000 kw. at a maximum velocity of water flow not to exceed 6 ft. per second.

The cooling-water discharge back into the river below the dam in front of the plant, is individual for each condenser, consisting of a cast-iron bell and spigot pipe line to a weir chamber at the river bank. This weir serves to seal or submerge the discharge line at all times and water level conditions in the river, thereby maintaining a vacuum condition in the condenser system. The weir proper is adjustable.

River water is undesirable for use in boilers and other purposes, so the raw boiler-feed water is taken from the city's water system.

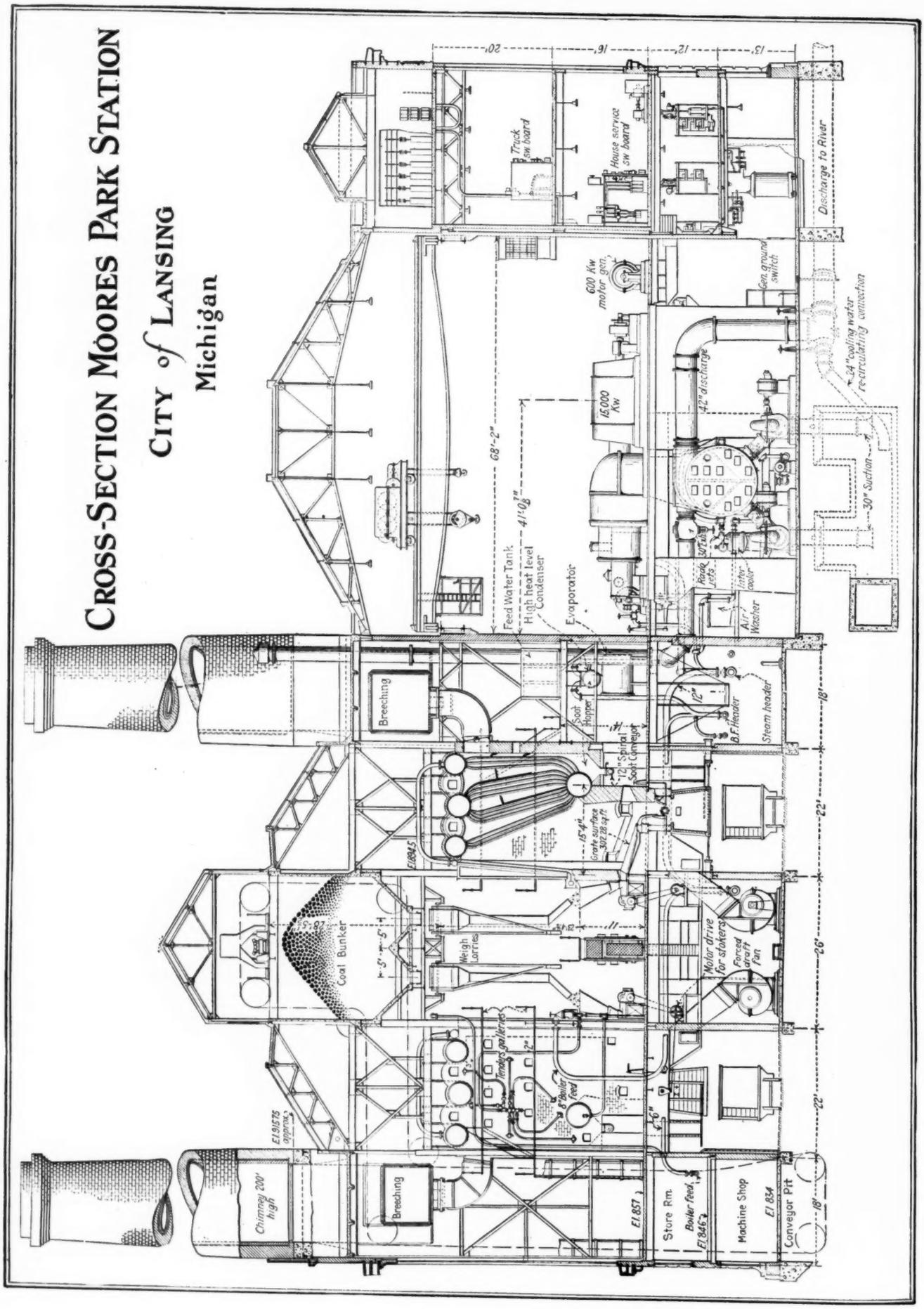
Outside Storage Provided for 20,000 Tons of Coal

The outside coal storage is located between two tracks 80 ft. center to center, and about 800 ft. of length between these tracks is available for an ultimate coal storage. On each track there are dumping pits for unloading cars for reclaiming by the locomotive crane, which will distribute it to any point in the storage pile. On the track immediately adjacent to the boiler-room side of the building there is a track hopper for unloading cars, which discharges to an apron conveyor which carries the coal into the building to the conveyer system.

The apron conveyor discharges into a motor-driven single-roll crusher which in turn discharges into a three-bucket filler for loading the conveyor proper. The present installation is served by a pivoted bucket conveyor of 75 tons per hour capacity at an operating speed of 40 ft. per min. This conveyor rises vertically and horizontally, and at the upper horizontal run it empties onto a belt conveyor which runs over the three bunkers. A hand-operated tripper on the belt conveyor permits the discharge of coal into any point of the three bunkers.

The ultimate plant will have a duplicate coal-handling system to serve three more bunkers and six additional boilers.

The coal bunkers are built into the building structure with side walls and bottoms of 3-in. gunite cement construction. Each bunker has four chain-operated valves to discharge into either of the weigh larries


Cross-Section Moores Park Station
City of Lansing
Michigan
Truck sw board
House service sw board
Discharge to River
600 kw motor gen.
Gen. ground switch
15,000 Kw
42" discharge
24" cooling water recirculating connection
30" Suction
Feed Water Tank
High heat level Condenser
Evaporator
Air Washer
Steam header
B.F. Heater
Soot Hopper
12" Spiral Soot Conveyor
Breeching
Coal Bunker
Weigh Larries
Timber gallleries
Boiler feed
Motor drive for stokers
Forced draft fan
Chimney 200' high
Store Rm.
Machine Shop
Conveyor Pit
68'-2"
41'-0 7/8"

in the firing aisle. Coal is fed to the boilers or stoker hoppers direct from the larries, and the operator weighs the coal and operates the larries from the walkway in the firing aisle 11 ft. above the floor.

The coal bunkers are approximately 25 by 30 ft. and 20 ft. deep and have a capacity of about 360 tons each, which provides a storage of sufficient fuel for four days' running at a normal rate of operation.

V-type, or vertical curved-tube boilers, six in number, each containing 15,000 sq.ft. of heating surface, furnish steam at 275 lb. gage. The peculiarity of the design of these boilers lies in the arrangement of the upper drums, of which there are three, the middle one being lower than the other two, and also in the disposition of the tubes. There are 880 of these, 55 tubes wide and 16 rows deep, divided into four banks. A radiant-heat bank of three rows connects the upper front drum with the lower or mud drum, two banks of four and five rows connect the middle upper drum with the lower drum, and one bank of four rows connects the rear upper drum with the lower drum. The baffles are placed on the back of the second and third banks, giving three passes for the gases, placing 385 of the total 880 tubes in the direct path of the hottest gases.

Three Boilers Equipped with Radiant-Heat Superheaters

Radiant heat superheaters are installed in three boilers, and by their construction across the entire front they supplement a front wall above the stokers. Each contains 300 sq.ft. of superheating surface. By the arrangement of elements and their cast-iron sleeves, the superheaters present a flat cast-iron surface to the fire

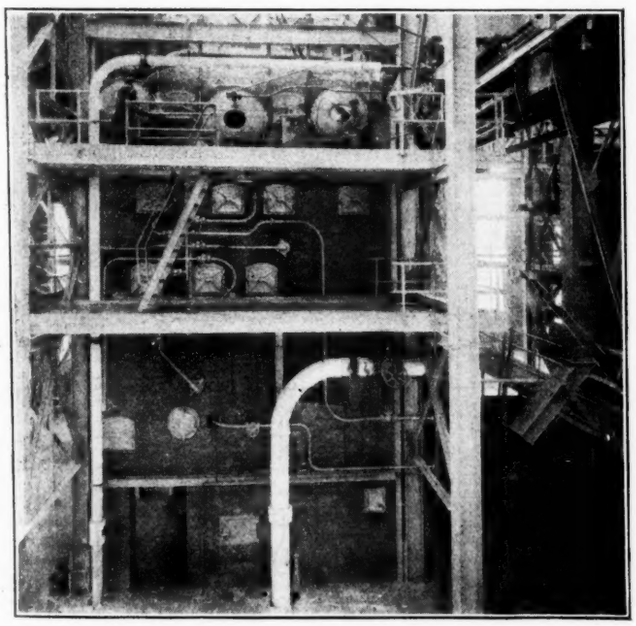


FIG. 4—SIDE VIEW OF 15,000-SQ.FT. BOILER

directly above the stokers and are designed to raise the steam temperature 200 deg. when the boilers are operating up to 200 per cent rating.

The superheaters installed in the other three boilers contain 1,700 sq.ft. of superheating surface each and consist of 78 units. The superheaters are between the first and second banks of boiler tubes and are designed to raise the steam temperature 200 deg. when the boilers are operating up to 200 per cent of rating.

The settings for the boilers are entirely of firebrick. Non-clinkering furnace blocks are introduced to prevent clinkering and slag adhesion to the front wall above the stoker under the superheater header and also to the side and bridge walls in the clinker-grinder pit. The side walls along the stoker proper are equipped with cast-iron high side tuyeres. Both the furnace blocks and the tuyeres are air ventilated from a connection

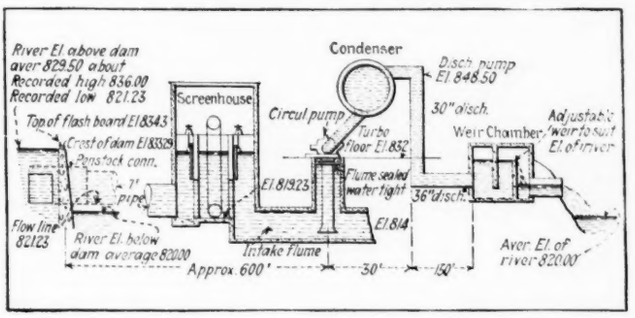


FIG. 5—ARRANGEMENT OF CIRCULATING-WATER INTAKE AND DISCHARGE THROUGH WEIR CHAMBER TO RIVER

taken off the main air duct under the stoker, and the air carried to the point of exit into the furnace, by ducts built in the boiler brick walls.

Cast-iron wall beams are built in the side wall above the stoker and adjacent to the fire and also in the short front wall over the stoker. These prevent the usual trouble encountered with this type setting, of the wall tending to fall inward, while the outside faces of the walls are well buckstayed with structural members that tie at the corners of the setting to sheet-steel corner plates built around the building columns. This installation of outside boiler-wall retainers is self-contained and in no way makes a connection to the structural steel of the building.

Stokers of the underfeed type of sixteen retorts each are installed under each boiler. These have a projected grate area of 302.28 sq.ft. and are capable of operating the boiler continuously at 250 per cent of rating and at 300 per cent to meet extreme conditions, when burning coal of at least 11,700 B.t.u. Each stoker is equipped with two sections of single-roll clinker grinder, each driven from the outside end. The stoker units are driven from an individual two-speed gear box, six for each stoker driven by a continuous shaft through them from a silent chain drive connection from a 1,500 r.p.m. motor located below the floor in the fan chamber. The clinker-grinder gear box or drive is actuated by a chain drive taken off the ends of the stoker driving shaft by means of an intermediary jackshaft. The clinker-grinder dump plates and grinding plates can be regulated by hand from the operating wheel at floor level.

Ash Gates Open from Center of Hopper

The ash is discharged from the clinker grinder into a sectional cast-iron hopper brick lined, with special overlapping tile, which is suspended from the girders at the boiler-floor level. Each hopper is equipped with four air-operated gates by means of which the ash can be dumped directly into standard railway cars on the tracks below in the boiler-room basement or into trucks. Each ash gate consists of two sections, which draw out to either side, and by parting at the center they discharge the ash directly in the center of the car below. The ash hopper is also larger at the bottom than

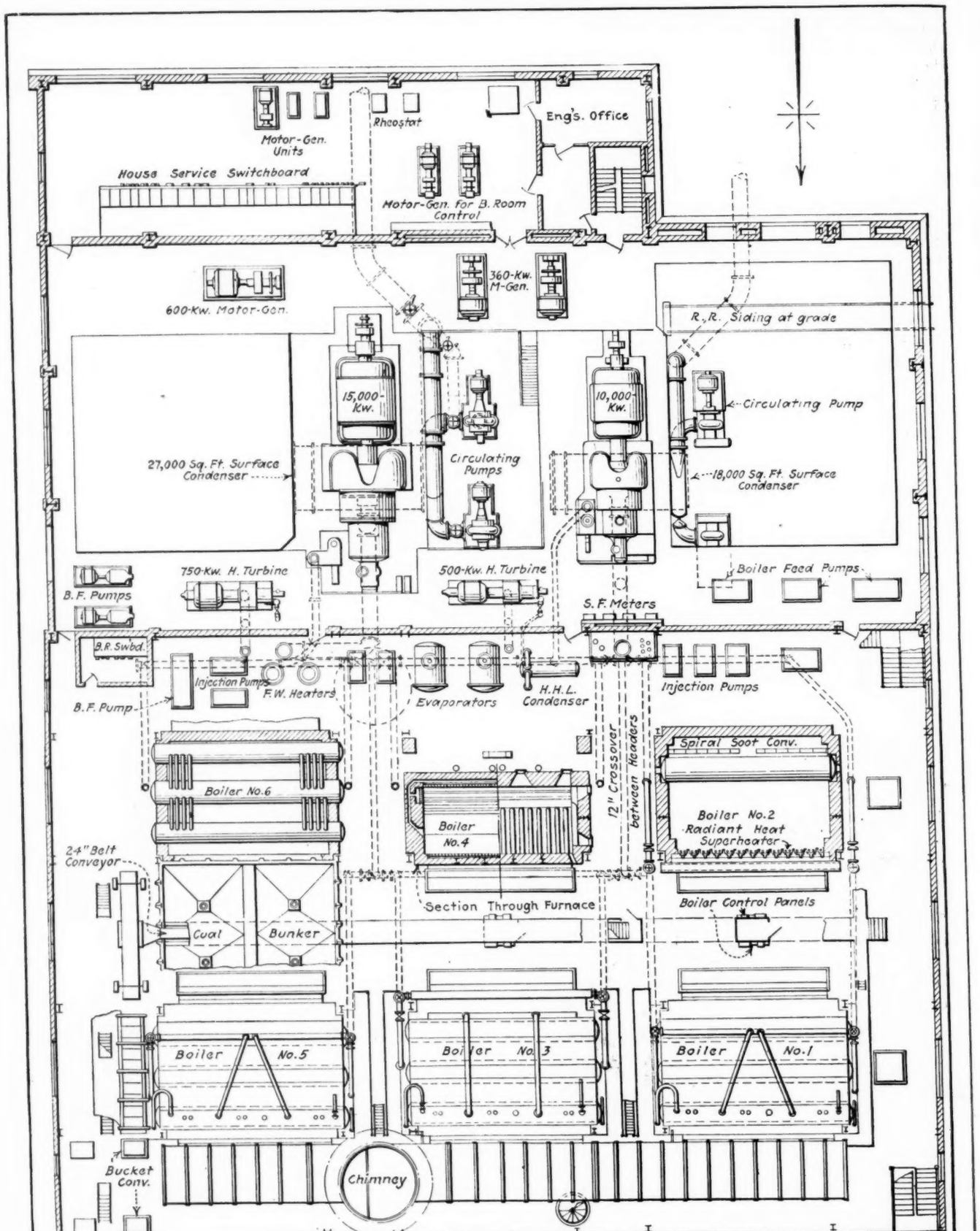


FIG. 6—PLAN OF 25,000-KW. SECTION OF STATION, SHOWS CROSS-SECTION OF BOILER SETTINGS AT DIFFERENT ELEVATIONS

at the top to prevent arching of the accumulated ash, and this feature, together with the double full opening gates, constituted a new design to eliminate operating difficulties and handle ashes at a minimum cost. The capacity of the ash hoppers is sufficient for a twenty-four-hour run in normal operation.

The forced-draft system consists of an individual fan and air duct for each boiler and stoker. Each fan is of a capacity to deliver 65,000 cu.ft. of air per minute against a static pressure of 6½ in. of water and is driven by a 120-hp. direct-current direct-connected motor. The fans are located in the fanroom below the firing aisle, and this room is constructed with louver air inlets on the west wall and is designed airtight to act as a arranged so that any individual motor can be operated manually or stopped and started without affecting the system, whereby their speeds could be varied to compensate for any irregularities of an individual furnace.

The boiler-control panels are mounted on structural frames in the firing aisle in front of each boiler. Each panel contains, in addition to the switching and other electric controls, the following instruments: Boiler meter combined to indicate and record steam flow, temperature and pressure, air flow and furnace temperature; CO_2 recorder; indicating draft gage for stack draft and furnace and wind-box pressures.

Direct current is used for all equipment which is under control of this system and this is supplied by

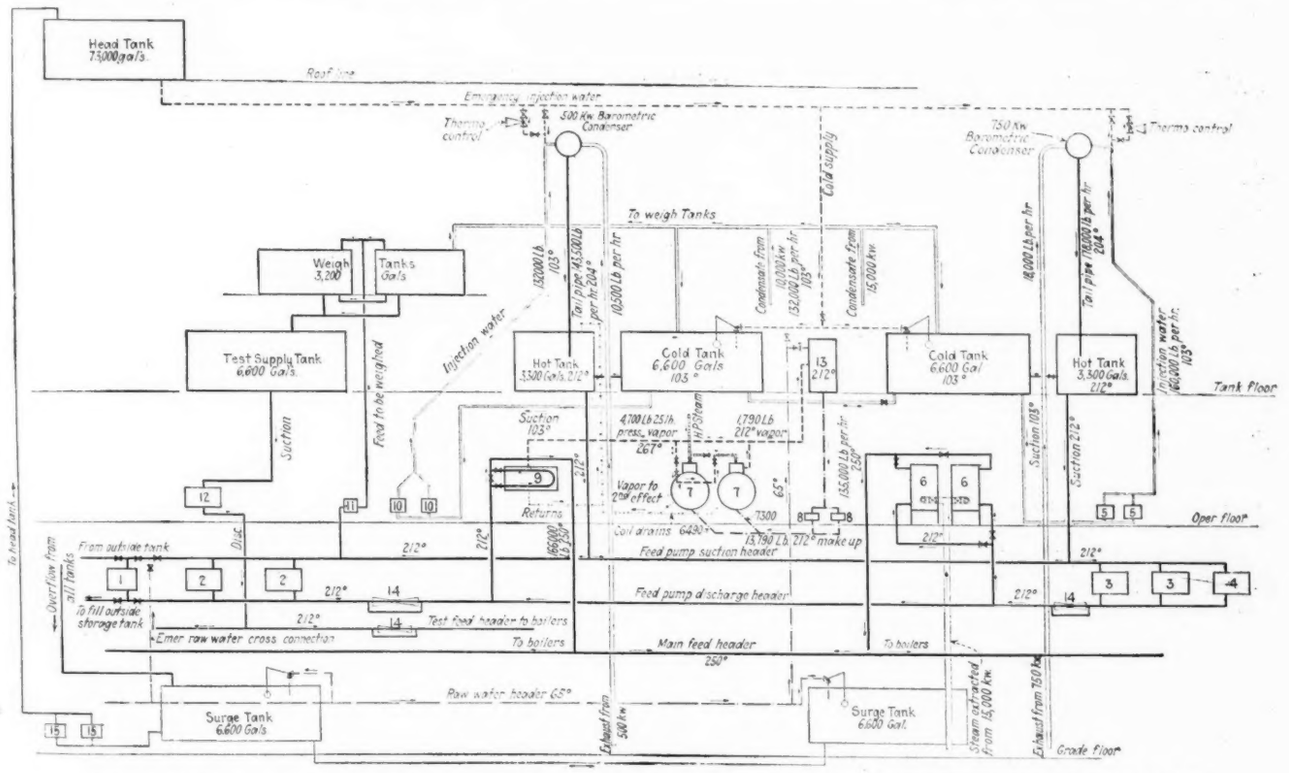


FIG. 7—GENERAL ARRANGEMENT OF PIPING AND AUXILIARIES FOR MAINTAINING HEAT BALANCE

1 and 3—Motor-driven boiler-feed pumps. 2 and 4—Turbo-driven boiler-feed pumps. 5 and 10—Motor-driven injection pumps for barometric condensers. 6—Closed feed-water heater. 7—Evaporators. 8—Steam-driven evaporator supply pumps. 9—High-heat-level condenser. 11—Motor-driven test supply pumps. 12—Turbo-driven test-feed pump. 13—Open feed-water heater. 14—Venturi, water-recording meters. 15—Surge pumps to fill head tank.

plenum chamber in connection with an air-preheating apparatus to warm the entire air in the fanroom by steam extracted from the first stage of the 15,000-kw. turbine.

Draft control is automatic, actuated by the boiler control system. The main dampers on each boiler outlet are operated and controlled by a motor-operated damper machine. The central point of control or regulation of the boiler control system is a steam-operated rheostat which acts directly to control the speed of a motor generator, supplying excitation to the direct-current motors serving for the supply of fuel and air in accordance with the steam demand by regulating the speed of the motor drives on the stoker and draft fans. The damper machine already mentioned operates to maintain a practically zero pressure in the combustion chamber for minimum rating, and the ratio is increased with increasing rate of operation to co-ordinate it with the supply of fuel, but is adjustable to conform to requirements of efficient combustion. All the motor drives are motor-generator sets in the switch-house installed especially for this purpose.

The main generating units are two in number, one of which is a 10,000-kw. and one 15,000-kw. The condensers are connected directly to the turbine exhaust outlets without expansion joints or intermediate valves. They are spring-supported on structural members built as a part of the turbine foundation. The turbine-room operating floor level is 25 ft. above the basement or grade floor, and each turbine is supported or built upon a separate concrete foundation, independent of the building structure.

Each condenser is equipped with two circulating pumps, one of which in each instance is capable of supplying sufficient cooling water when the river water is at the usual winter temperature 40 to 50 deg. F. In extremely warm weather this temperature will exceed 75 deg., at times requiring the use of both circulating pumps.

The condensate pumps are directly under the con-

DATA ON MECHANICAL EQUIPMENT MUNICIPAL POWER PLANT, LANSING, MICH.

Capacity:	
Ultimate	55,000 kw.
Installed (One 15,000 kw., one 10,000 kw.)	25,000 kw.
Nature of Load served:	
City lighting and industrial and domestic electric consumption.	
Length of turbine room inside	148 ft. Ultimate 285 ft.
Width of turbine room inside	68 ft., 2 in.
Width of electrical bay	26 ft.
Length of boiler room	148 ft. Ultimate 285 ft.
Width of boiler room	103 ft.
Distance from basement or grade floor to turbine-room operating floor	25 ft.
Distance from basement floor to boiler-room operating floor	23 ft.
Distance from turbine-room operating floor to lower chord of roof truss	46 ft., 6 in.
Ratio of boiler heating surface to boiler room floor area with all boilers installed	5.4
Width of firing aisle	24 ft.
Width of passage behind boilers next to turbine room	18 ft.
Width of passage behind boilers next to outside wall	18 ft.
Width of passage between boilers	12 ft.

BOILERS AND SUPERHEATERS

Manufacturers	Heine Boiler Co.
Type	"V" type, radial tube similar to Stirling
Number: Ultimate	Twelve
Installed	Six
Steam drums	Three—one 48 in., two 42 in. dia., all 31 ft. 9 in. long
Mud drum	One 48 in. dia., 28 ft. 6 in. long
Plate thickness	48 in. drums 1⅛ in., 42 in. drums 1 $\frac{1}{16}$ in. thick
Tubes	880 long tubes and 330 circulators per boiler all No. 9 BWG, 3¼ in. outside diameter
Heating surface	15,000 sq.ft.
Heating surface per installed kw. capacity normal rating	3.6
Boiler pressure, lb. gage	275
Total temperature, deg. F.	609
Superheaters:	
3 radiant heat, 300 sq.ft. (Foster)	Power Specialty Co.
3 Elesco, 1,700 sq.ft.	Superheater Co.
Superheaters performance	200 deg. F. at 200 per cent rating
Boilerheating surface per sq.ft. of superheating surface:	
Foster	50 sq.ft.
Elesco	8.82 sq.ft.
Superheating surface per sq.ft. of grate area:	
Foster	1.0 sq.ft.
Elesco	5.6 sq.ft.

Coal Analysis:	Illinois	W. Va.
Fixed carbon	37.5	56
Volatile Hydro-carbon	39	33
Sulphur	High	.....
Moisture	9.5	1.0
Ash, per cent	14	10
B.t.u. per pound of dry fuel	11,700	14,000

Boiler Settings:

Constructed of all firebrick (no arches)
Side and front walls reinforced with the Lawrence type wall beams
High side wall tuyeres installed along side of stokers at fire line
Front wall over stoker and side and bridge wall in clinker grinder pit built with non-clinkering furnace blocks.

Height of steam drums above operating floor	31 ft. 6 in.
Height of center of superheater header at front above operating floor	12 ft. 0 in.
Furnace volume	8,580 cu.ft.
Per square foot grate area	28 cu.ft.
Per stoker retort	536.2 cu.ft.

Rate of operation	Pounds of Coal Fired per Hour per Cu.Ft. of Volume
150 per cent rating	1.00
200 per cent rating	1.13
250 per cent rating	1.80

BOILER PASSES

Free area opening, first pass	275 sq.ft.
Free area opening, second pass	82.5 sq.ft.
Free area opening, third pass	82.5 sq.ft.

STOKERS

Manufacturer	Sanford Riley Stoker Co.
Type	Underfeed
Number of retorts	16
Drive	Adjustable speed d.c. motor, 25 hp.
Clinker grinder, type	Single Roll
Clinker grinder drive	from stoker motor drive via a jackshaft
Projected grate area	302.28 sq.ft.
Ratio water heating surface to grate area	48.8

Stoker Performance based on coal (11,700 B.t.u.)

Rate Operated, Per Cent	Comb. Boiler & Furn. Eff. Per Cent	Coal per Retort	Lb. Coal per Sq.Ft. Grate Area per Hour
150	77	539	28
200	74½	605	38
250	70½	972	50.5

Number of hours capacity ..... 2 at 300 per cent rating

FORCED-DRAFT FANS

Manufacturer	B. F. Sturtevant Co.
Number installed	Six: one per boiler
Type of fan	Radial-flow double-inlet
Capacity	65,000 cu.ft. per minute
Drive	Motor 120 hp.
Fan capacity per sq.ft. of grate area	215 cu.ft.
Fan capacity per cu.ft. of furnace volume	7.6 cu.ft.

COAL-HANDLING EQUIPMENT

1 Pivoted-bucket conveyor	C. W. Hunt Co.
Capacity at 40 ft. per min., tons per hour	75
Drive	20-hp. motor
1 Belt conveyor, 24 in.	Robins Conveyor Belt Co.
Drive	7.5-hp. motor
1 Crusher, 24 x 30 in. single roll	Pennsylvania Crusher Co.
Drive	30-hp. motor
1 Apron Feeder, 38 in.	Weller Mfg. Co.
Drive	7 5-hp. motor
2 Weigh Larries (motor-driven)	Weller Mfg. Co.
Capacity each, tons	2
Bunkers	Reinforced concrete 1,080 tons
Storage capacity (yards)	20,000 tons

ASH-HANDLING EQUIPMENT

Ash gates (two, opening from center)	Compressed-air operated
Manufacturer	Baker-Dunbar-Allen Co.
Ash Disposal	Into Standard railway cars

MAIN GENERATING UNITS

Manufacturer	Allis-Chalmers Co.
Number Installed	2
Capacity	1—10,000 kw. 1—15,000 kw.
Type	Horizontal reaction
Speed r.p.m.	1,800
Generator	3 phase, 60 cycle, 13,200 volts

Guaranteed Performance on 29 In. Vacuum

10,000 Kw. Unit: Kw. Output of Generator	10,000 Kw. Unit: Lb. of Steam per Kw.-Hr.	15,000 Kw. Unit: Kw. Output of Generator	15,000 Kw. Unit: Lb. of Steam per Kw.-Hr.
5,000	12.15	7,500	11.46
7,500	11.53	11,250	10.66
10,000	11.22	13,150	10.48
		15,000	10.59

	10,000 kw.	15,000 kw.
Floor area (sq.ft.)	554	800
Capacity per sq.ft. of floor area	18.2	18.5
Weight of turbine per rated kw.	32.5	30.0
Extraction connections	None	10 in. 1st. stage 12 in. 2d. stage

HOUSE-TURBINE UNITS

Manufacturer	Allis-Chalmers Co.
Type	Horizontal reaction
Speed r.p.m.	3,600
Number installed	2
Capacity	1—500 kw. 1—750 kw.
Generator	3-phase, 60-cycle, 480-volt
Guaranteed performance	

500 Kw. Unit: Kw. Output of Generator	500 Kw. Unit: Lb. of Steam per Kw.-Hr. With 2-In. Vac.	500 Kw. Unit: Lb. of Steam per Kw.-Hr. With 10-In. Vac.	750 Kw. Unit: Kw. Output of Generator	750 Kw. Unit: Lb. of Steam per Kw.-Hr. With 5-In. Vac.
300	29.3	28.5	450	27.6
400	27.0	26.2	600	25.2
500	25.5	24.7	750	23.8

CONDENSERS

Manufacturer (10,000 kw. unit)	Allis-Chalmers Co.
Type	Surface
Cooling surface, sq.ft.	18,500
Tubes, 1 in. x 18 ft. No. 18 gauge	seamless brass
Steam condensed lb. (60 deg. cir. water 29 in. vac.)	132,000
Circulating pumps, two 24 in.	Allis-Chalmers Co.
Type	Centrifugal
Capacity, gal. per min.	11,500
Speed r.p.m.	353
Total working head, ft.	15
Drive	Direct-connected 60-hp. 440-v. motor
Condensate Pumps (two 5 in.)	Allis-Chalmers Co.
Type	Centrifugal
Capacity, gal. per min.	530
Speed r.p.m.	1,750
Total working head, ft.	80
Drive	Direct-connected 25-hp., 440-v. motor
Air Pumps	Croll-Reynolds Co. Inc.
Number	2
Type	Two-stage evactor
Manufacturer (15,000 kw. unit)	C. H. Wheeler Mfg. Co.
Type	Surface
Cooling surface, sq.ft.	27,000
Tubes 1 in. dia. x 19 ft. No. 18 gage	S. D. Muntz Metal
Steam condensed, lb. (58 deg. cir. water 29 in. vac.)	170,000
Circulating pumps (two 30 in.)	C. H. Wheeler Mfg. Co.
Type	Centrifugal
Capacity, gal. per min.	17,250
Speed, r.p.m.	350
Total working head, ft.	10
Drive	Direct-connected 100-hp., 440-v. motor
Condensate pumps (two 8-in.)	C. H. Wheeler Mfg. Co.
Type	Centrifugal
Capacity, gal. per min.	800
Speed r.p.m.	1,750
Total working head, ft.	50
Drive	Direct-connected 50-hp., 440-v. motor
Air pumps	C. H. Wheeler Mfg. Co.
Number	2
Type	Radojet
Condensers (for house turbines)	Allis-Chalmers Co.
Number	2
Type	Barometric
Size	24 in. with 12 in. exh inlet 6 in. x 22 ft. tail pipe
Air Pumps	Croll Reynolds Co., Inc.
Number	4
Type	Single stage evactor
Injection pumps	Allis-Chalmers Co.
Number	4
Type	Centrifugal
Size, in.	3
Capacity, gal. per min.	265
Boiler-Feed pumps	Allis-Chalmers Co.
Type, One 315 g.p.m., 3 in. 6-stage motor-driven, 125 hp. Two 315 g.p.m., 3 in. 4-stage turbine-driven, 100 hp. One 600 g.p.m., 5 in. 7-stage turbine-driven, 125 hp. Two 600 g.p.m., 5-in. 7-stage motor-driven, 125 hp.	

DATA ON MECHANICAL EQUIPMENT, MUNICIPAL POWER PLANT, LANSING, MICH. (*Continued*)

HEATERS AND EVAPORATORS

Two closed heaters	Griscom-Russell Co.
One open heater	H.S.B.W. Cochrane Corp.
Two Reilly submerged-type evaporators	Griscom-Russell Co.
One 4-pass high-heat level condenser	Griscom-Russell Co.
Two evaporator feed pumps	Epping Carpenter Co.
Type	7½ x 4½ x 6 in. duplex

BOILER CONTROL SYSTEM

Manufacturer	The Benjamin Engineering Co.
Type	Control forced draft and stoker equipment
Feed Water Regulator (Copes)	Northern Equipment Co.

METERS AND INSTRUMENTS

Boiler Meters	Bailey Meter Co.
CO_2 Recorder (Mono)	C. J. Tagliabue Co.
Indicating Draft Gages	Bailey Meter Co.
Venturi Meters	Builders Iron Foundry
Steam-Flow Meters	Bailey Meter Co.
Water-Flow Meters (Condensate Disch.)	Bailey Meter Co.

MISCELLANEOUS EQUIPMENT

1—Boiler test pump 315 g.p.m.	Allis-Chalmers Co.
1—Test supply pump 4 in.	Allis-Chalmers Co.
4—Surge pumps 2-in. single-stage	Allis-Chalmers Co.
2—Traveling screens	Chain Belt Co.
2—Air washers	Spray Engineering Co.
2—Air washers	Cooling Tower Co.
Temperature control for Bar. Cond.	C. J. Tagliabue Co.
Soot blowers	Vulcan Soot Cleaner Co.
Non-clinkering furnace blocks	Furnace Engineering Co.
Chimneys	Alphonse Custodis Chimney Con't. Co.
Type	Radial Brick superimposed
Height, ft., (above grates)	250
Smoke flues and forced-draft air ducts	Muskegon Boiler Works & Littleford Bros.
Traveling crane	Whiting Corp.
Locomotive crane	Brown Hoisting Mchry. Co.
Feed-Water Storage Tanks, one—Outside Elevated Storage Tank, 50,000-gal. capacity	Pittsburgh Des Moines Steel Company
12 tanks, feed water and service	Wickes Boiler Co. and Muskegon Boiler Works
Air Compressors	Chicago Pneumatic Tool Co.
One—9x8-in.x176 cu.ft. per min.	
One—10x10-in.x600 cu.ft. per min.	
Oil purifier, De Laval Portable 5-bbl. capacity	De Laval Separator Co.
Richardson-Phenix furnished by	Turbine manufacturer
Main Steam Valves	National Valve & Mfg. Co.
	Nelson Mfg. Co.
Relieving Gate Valves	Nelson Mfg. Co.
Boiler non-return	Nelson Mfg. Co.
	Edward Valve & Mfg. Co.
Blowoff valves	Nelson Mfg. Co.
	Edward Valve & Mfg. Co.
Standard valves	National Valve Co.
Atmos. relief valves	Atwood & Morrill Co.
Boiler safety valves	Ashton Valve Co.
Motor generators	Allis-Chalmers Co.
Station transformers	Allis-Chalmers Co.
Switchboards	General Electric Co.
Standard and extra-heavy steam piping	National Valve & Mfg. Co.
Special oil-treated studs for pipe flanges	Bethlehem Steel Co.
Rubber expansion joints	U. S. Rubber Co.
Copper expansion joints	E. B. Badger & Sons Co.
Indicating and recording thermometers	Bristol Co.
Indicating and recording pressure gages	American Steam Gage & Valve Co.
Building contractor	Frank H. Davis Co., Detroit
Consulting engineer	J. E. Woodwell, New York

denser hotwell, and on the 10,000-kw. unit the pumps discharge the condensate direct to the cold tank. The 15,000-kw. condensate pumps discharge the condensate into an inter and after condenser in connection with the air pumps. This condensate, acting as a cooling water, gains five degrees in temperature at normal operation.

The air-removal pumps on the 10,000-kw. unit are of the Evactor type and are installed in duplicate, though either set is capable of removing the air under full load. On the 15,000-kw. unit the Radojet air pumps are used and exhaust into the intercooler or condenser previously mentioned. The Evactor exhausts directly to the hot tank, where the condensation from the Radojet from the intercooler is trapped back into the main-condenser hotwell.

Each of the generators of the main turbines is equipped with closed-circuit air washers consisting of a galvanized-iron housing completely inclosed with the foundation. Thermostatic alarm gongs are installed to warn the operators of a rise in the air temperature, and emergency dampers provide for temporary operation where cool air is taken directly from and discharged back into the turbine room. Under ordinary conditions the same air is recirculated, washed and cooled continually.

All auxiliaries except three boiler-feed pumps and a boiler-test pump are motor driven. A 500-kw. and a 750-kw. house turbine are installed, which primarily take care of the electric auxiliary motor drives. In addition to this these units furnish power to motor-generator sets which in turn furnish direct current for draft fans and stoker motors and other boiler control apparatus. These house turbines float on the line and operate at such load as is required to give a proper heat balance in the station.

Feed-water distillation and preheating is taken care of by a combined system of evaporators, open and closed feed-water heaters.

Two evaporators are installed which can be operated in either single or double effect to take care of the actual purification of the necessary makeup water of 12,000 lb. per hour maximum. The raw water for the evaporators is first introduced into an open feed-water heater which uses some vapor and other exhaust steam as a heating medium. This heater acts as a hotwell for the evaporator supply pumps.

The exhaust from the house turbines is passed through barometric condensers, the tail pipes of which discharge into the hot tanks. The injection pumps for these condensers take their suction from the cold tanks with which the condensate from each of the main condensers is discharged.

The recovered steam exhaust from both the main and house turbine units is then stored in the hot tanks from which the boiler-feed pumps take their suction. In addition to the exhaust from the house turbines the barometric condensers also take care of the exhaust from the turbine-driven boiler-feed pumps. Two closed feed-water heaters are installed as a supplementary preheating for boiler feed. These are furnished with steam extracted from the first stage of the 15,000-kw. unit.

The boiler-feed water discharged from the pumps at 212 deg. is then pumped through a high-heat-level condenser on its way to the boilers. In this final passage the boiler feed serves as cooling water to condense vapor from the evaporators furnished to this condenser. This last heat transfer brings the ultimate temperature up to 245 to 260 deg. at 280 lb. pressure.

There are two surge tanks in the boiler-room basement for storage of all overflows from other tanks and any other water discharge from equipment. This water is pumped to the head tank on the roof, which is used as an emergency injection for the barometric condensers and is thermostatically controlled. The gland water for the main turbines is also stored in a separate tank on the roof.

A 50,000-gal. overhead storage tank is installed outside the plant, and this can be filled by a cross-connection with one of the motor-driven boiler-feed pumps. This affords an ample storage of distilled water at all times.

The main steam piping is entirely below the operating floors, the leads down from the superheaters being the only piping visible in the boiler room. There is one header in the pipe gallery and another in the fanroom, and these are cross-connected with 12-in. crossovers, affording the maximum flexibility in operation. The leads to the main and house turbines are all taken off the header in the pipe gallery as shown in the plan and cross-section. This piping is all designed suitable for

350 lb. working pressure and is all square-cornered Vanstone joints, with high tensile-strength bolts used throughout.

The feed headers are of the same general arrangement with a separate system of headers provided to test boilers. There is a complete system of weigh and storage tanks and an individual boiler test and supply pumps installed to test any boiler in the plant without interfering with the plant operation. Either of the main turbines can be tested and the condensate weighed by the boiler-testing system.

The main generating units are connected to a double 13,200-volt bus by means of interlocking selector oil circuit breakers. The generators are star-connected with neutral grounded through differential protected oil circuit breakers. In the basement of the switch bay there are four 3,333-kva. 13,200/4,000-volt step-down transformers, each transformer being in a separate vault to minimize fire hazard. Connections are arranged so that the fourth transformer may readily be cut into service to take the place of any one of the other transformers in case of trouble.

In the basement are also three 200-kva. 13,200/440-volt transformers for house-service auxiliaries, and two 50-kva. transformers for station lighting.

On the level immediately above the transformers is the 13,200-volt double bus structure and motor-operated oil circuit breakers. At one end of this floor, in a separate room, is the storage battery which supplies energy for operation of high-tension switches, station trips, emergency lighting, excitation for house turbine, etc.

Buses Extended to Distribution Center in Plant

On the level next above are the house-service switchboard, the battery charging sets, motor-driven turbine exciters, and the three-unit motor-generator set for the boiler-control system. Extending from the house-service switchboard across the main turbine room and protected by a walkway at one end of the room, 440-volt alternating-current and 250-volt direct-current buses are run to a subcenter of distribution in the boiler-house end of the station. From this latter point, which is the local load center, connections are run to all boiler auxiliaries. The extension busbars are equipped with disconnecting switches at the house service board. The use of this bus-extension method eliminated practically all under-grade house-feeder runs, thus doing away with a potential source of trouble and hazard of cable failures.

Above the house-service board level and with a balcony overlooking the main turbine room is the benchboard. This is the control center of the station. The benchboard controls main generator switches and all outgoing 13,200-volt feeders and also switches for control of main and house transformer banks.

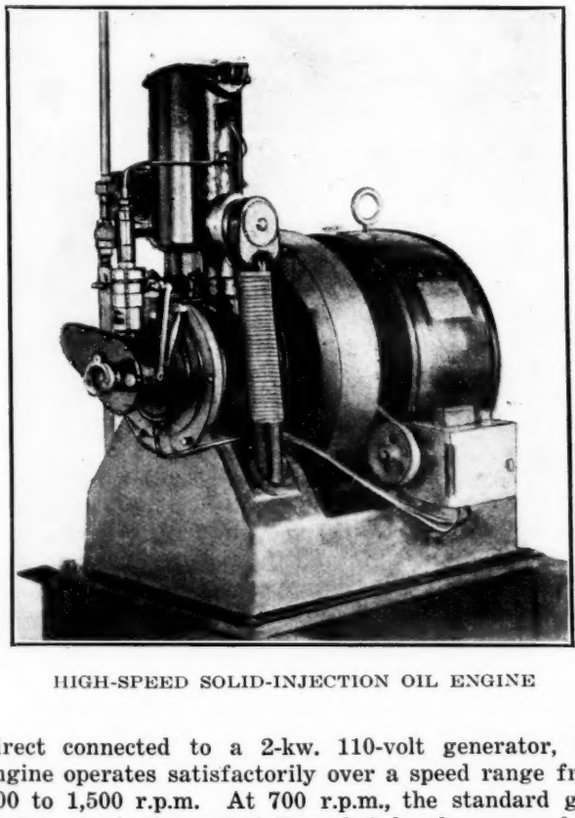
Otto Ziegler is president of the Board of Water and Electric Light Commissioners; O. E. Bulkeley is superintendent and W. B. Kirby is secretary. The building project was handled by a building committee consisting of Hugo Lundberg, J. P. Hopkins and A. D. Wilkins, acting with President Ziegler.

J. E. Woodwell, 501 Fifth Avenue, New York City, is the consulting engineer retained for the work of appraisal, designs, plans and supervision of the construction of the new generating station, substations, and the revamping of the electric distribution system of the city.

Small Solid-Injection Oil Engine

It is assumed by most engineers that the solid-injection oil engine cannot be successful when built in small sizes, consequently it is seldom that machines of this type are under 10 horsepower.

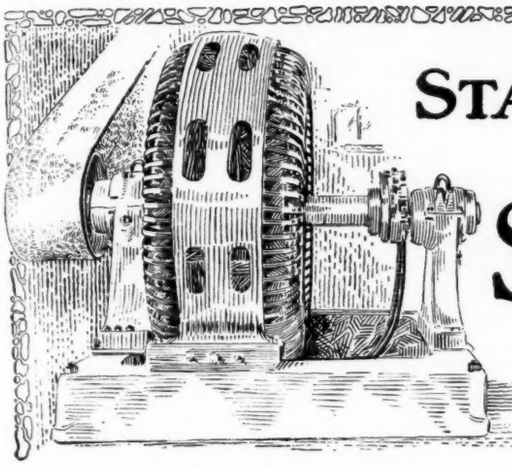
The Galt Motor Co., Galt, Ontario, has brought out a small engine that disproves this idea. The machine, which is shown in the illustration, is of the two-stroke-cycle type with a compression pressure of 350 lb. The crankcase is used as the scavenging pump, delivering air at 15 lb. pressure to the working cylinder. When



HIGH-SPEED SOLID-INJECTION OIL ENGINE

direct connected to a 2-kw. 110-volt generator, the engine operates satisfactorily over a speed range from 100 to 1,500 r.p.m. At 700 r.p.m., the standard generator speed, the unit delivered 6 kw.-hr. per gal. of fuel oil. The fuel is injected into the combustion chamber through a single nozzle, the fuel-pump timing being such that injection starts 5 deg. ahead of dead center and at full load the injection ends at 20 deg. past dead center.

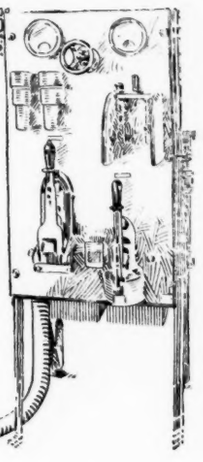
If an attempt were made to start a motor with a group of coils short-circuited, it would act as though starting under a heavy overload and would draw such a large current from the line as to cause the starting resistance to reach an excessive temperature in a very short period. The effect of this fault on a generator would depend upon the conditions under which it occurred. If the machine built up the voltage as it came up to speed, it would act as if it were heavily overloaded before it reached full speed. On the other hand, if the voltage did not build up until after the machine reached full speed, then when it did, the excessive current flowing in the armature coils would cause a heavy overload on the prime mover and slow it down; also, before the machine could be shut down the temperature of the coils would probably become so high as to destroy their insulation.



STARTING SYNCHRONOUS MOTORS

by

Gordon Fox *



Self-Starting Motors—Development of Starting Torque—Requirements of Static and Pull-In Torque—Effects of Squirrel-Cage Winding Resistance on Torque—How Synchronous Speed Affects Starting Current—Three Methods of Starting

A SYNCHRONOUS motor develops torque due to pure synchronous-motor action only when running at synchronous speed. It was formerly customary to accelerate these motors from rest by means of a small auxiliary induction motor or, in the case of a motor-generator set, to utilize the direct-current end of the unit for this purpose. If an auxiliary induction motor is used, it has less poles than the synchronous motor, so that its synchronous speed is greater than that of the larger machine. Primary-voltage control is then commonly applied to the auxiliary unit in order to adjust the speed to permit synchronizing the larger motor. Equipments of this type are intended to start without load, thus reducing the size of the auxiliary motor.

Self-Starting Type Motor

The great majority of polyphase synchronous motors are now of the self-starting type. These motors function as induction motors during the starting period, synchronous motor action becoming effective at speeds slightly below synchronism. Since an induction motor never attains synchronous speed, it follows that a synchronous motor cannot be brought to synchronous speed purely through induction-motor action. At speeds below synchronism with the field poles excited, impulses are set up by synchronous-motor action; that is, attraction and repulsion between unlike and like poles of the stator and rotor. As the rotor poles slip past the stator poles, these impulses are alternately favorable and then opposed to the rotation. As the slip decreases, these impulses become greater in magnitude and duration. If the motor is accelerated, by induction-motor action, to a speed sufficiently near synchronism, say within 3 to 6 per cent, these impulses attain such magnitude that, if the load and inertia to be accelerated are not too great, the motor will be pulled into and hold in step by the synchronous-motor torque. The nearer the motor approaches synchronous speed by induction-motor action, the greater and more prolonged are the synchronizing torque impulses and the less is the inertia and obstacle to pulling into step.

Since the synchronous motor functions as an induction motor when starting, its performance is then governed largely by the measure in which it attains the design features of induction motors having good starting characteristics. Practically all self-starting synchronous motors are provided with a squirrel-cage winding embedded in the pole pieces, as shown at *S* in Fig. 1. This winding is the principal factor in the development of starting torque although some torque is added, due to hysterisis and eddy currents in the field poles themselves. Currents induced in the rotor-field coils, if their circuit is closed, produce a torque that opposes the rotation at about half synchronous speed, but which assists the rotation at speeds slightly below the synchronous.

Factors that Influence Motor's Torque

Since a self-starting synchronous motor must perform both as a synchronous and as an induction machine, the design is generally a compromise. Factors that lead to high starting torques in the induction motor are low magnetic leakage and high rotor resistance. The magnetic leakage in a synchronous motor is necessarily high, as a fairly wide air gap is desirable. The use of definite poles, as contrasted with the smooth drum rotor of the induction motor, also tends to increase magnetic leakage. On the other hand, a high rotor resistance may be used if desired. The rotor resistance of the squirrel-cage induction motor is normally made quite low in order to restrict the rotor losses, to maintain good efficiency and prevent undue heating. Consequently, the standard squirrel-cage induction motor is somewhat deficient in starting torque. The cage winding of the synchronous motor functions only during the starting period, hence the secondary losses are of importance only from the aspect of heating and not as affecting running efficiency. It is not exceptional to find synchronous motors with high-resistance cage windings which will develop starting torques equaling or exceeding those which would be developed by squirrel-cage induction motors of similar rating.

In order that a synchronous motor may pull into step, it is necessary to accelerate it until synchronous speed is quite closely approached. The nearer synchronous speed is reached the more powerful is the

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synchronizing action. The slip of an induction motor depends upon the load and also upon the resistance in the cage winding. If a high-resistance cage be used in order to provide a high torque at starting, it is possible that the slip will be so great that sufficient synchronizing action cannot be developed to pull the motor into step. In Fig. 2 are shown the starting torques developed by a motor with cage winding of high resistance using brass bars and also with a cage winding of low resistance using copper bars. It is evident that the high-resistance cage winding gives the higher static torque, about twice that for the copper winding. On the other hand the low-resistance cage winding enables a greater load to be carried with a given slip or a given load with less slip. It will be seen from the figure that at about 90 per cent synchronous speed, that is, 10 per cent slip, the low-resistance winding develops about 3.5 times the torque of the high-resistance winding. The design of the cage winding for a motor must be a compromise between these extremes and is governed largely by the characteristics of the load to be started. For instance, a centrifugal pump or blower requires a low static torque, but the torque demand may increase rapidly with the speed. A motor with a low-resistance cage winding is well suited for such an application. On the other hand, a pulp grinder may require a high torque to overcome static friction, but a relatively low torque suffices to maintain rotation. For such an application a motor with a high-resistance cage winding is adapted.

Two Requirements in Motor Starting

From the foregoing it is evident that the starting of a synchronous motor involves two distinct requirements; namely, starting and pull-in torques. These requirements are more or less opposed in their design influence. Means have been devised and used by some manufacturers to obtain high starting torques without excessive slip. One method now practiced involves the use of tubular copper or brass bars in the cage winding.

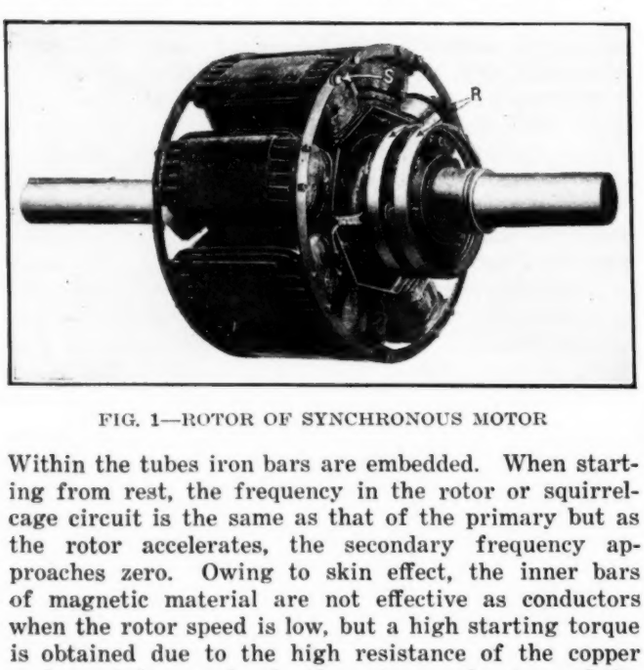


FIG. 1—ROTOR OF SYNCHRONOUS MOTOR

Within the tubes iron bars are embedded. When starting from rest, the frequency in the rotor or squirrel-cage circuit is the same as that of the primary but as the rotor accelerates, the secondary frequency approaches zero. Owing to skin effect, the inner bars of magnetic material are not effective as conductors when the rotor speed is low, but a high starting torque is obtained due to the high resistance of the copper or brass tubes used. As the rotor accelerates and the secondary frequency falls, the skin effect decreases and the effective resistance of the cage winding is reduced. Thus the motor is given the characteristic of a high-resistance squirrel cage to develop good static torque, but also secures the advantages of a low-resistance cage in minimizing the slip. Similar results may be secured by the use of deep rotor bars which have low resistance but high reactance at low speed when the rotor frequency is high. By this scheme the rotor impedance at low speed is made greater than at high speed, giving the motor the starting characteristics of a

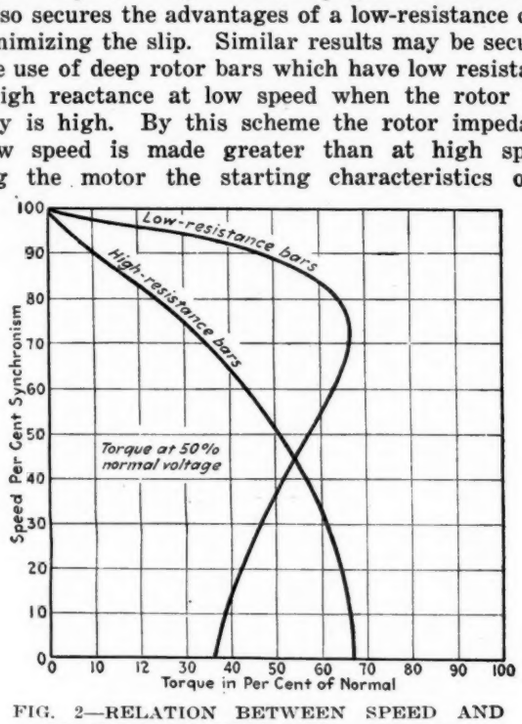


FIG. 2—RELATION BETWEEN SPEED AND TORQUE WHEN USING HIGH- AND LOW-RESISTANCE STARTING WINDINGS

high-resistance rotor and the pull-in ability of a low-resistance rotor. Another method of obtaining high starting torque is to mount the stator in bearings and allow it to come up to synchronous speed with the rotor at rest. After closing the field switch, a brake is applied to the stator frame and it is gradually brought to rest while the rotor is coming up to synchronous speed. This arrangement allows the motor to develop a starting torque equal to its pull-out torque.

High Starting and Pull-in Torque

As previously indicated, it is possible to design motors to develop high starting torque only or high pull-in torque alone, but it is more difficult to combine the two and not possible to obtain both features to maximum degree in the ordinary type of motor. High pull-in torque is the more difficult condition to meet. In general, high-speed designs exert somewhat better starting torques than low-speed designs. It is difficult to state accurately what starting performance is representative, as development is rapid and manufacturers' statements vary. The following values are probably fairly representative of the best performance generally available. Motors of 180 r.p.m. and above can be made to develop about 90 per cent pull-in torque at about 80 per cent voltage with a corresponding static torque of about 35 per cent. Lower-speed motors can be made to develop about 50 per cent pull-in torque under similar conditions. Motors of all speeds may be had to develop 100 to 150 per cent starting torque at about 80 per cent voltage, but will have a low pull-in torque of about 15 to 25 per cent. The corresponding starting peaks will be about 250 to 300 per cent normal full-load current. The synchronous motor is superior to the squirrel-cage induction motor in starting performance if a high starting torque and low pull-in torque are required. The squirrel-cage induction motor is supe-

rior if the torque near synchronous speed is relatively high. The wound-rotor induction motor is superior to both.

One of the limiting factors in the development of high-starting duty from self-starting synchronous motors is the heating of the squirrel-cage winding. The rather high resistance necessary to obtain high starting torque causes appreciable secondary losses. The cage winding cannot fully dissipate these losses, and the heat-storage capacity of this winding cannot be great, as the winding must be inserted in the field pole pieces.

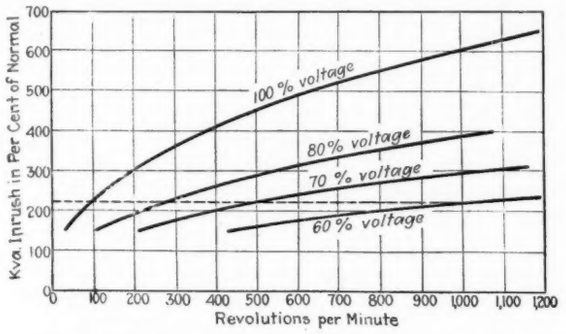


FIG. 3—CURVES SHOWING STARTING KILOVOLT-AMPERES TAKEN BY SYNCHRONOUS MOTORS OF DIFFERENT SPEEDS

For these reasons it is necessary that a self-starting synchronous motor be capable of accelerating its load to synchronism quickly, say in less than one minute, otherwise the cage winding may become overheated.

Heavy Current Inrush Objectionable

Another consideration that limits the starting torque that may be secured from a self-starting synchronous motor is the heavy current inrush involved. This inrush is particularly objectionable in that the power factor at starting is low. During this period the magnetization must be supplied from the alternating-current system. The starting torque developed per kilovolt-ampere input by a synchronous motor with a low-resistance squirrel-cage winding will be less than that of a standard squirrel-cage induction motor. The starting torque developed per kilovolt- ampere input by a synchronous motor with a high-resistance cage winding will be higher than that of a standard squirrel-cage induction motor. When running near synchronism the motor will draw a larger kva. from the line than would a similar induction motor. This is due to the heavier magnetizing current required largely because of the wider air gap and definite-pole construction of the synchronous machine.

The power factor of the synchronous motor at starting is usually about 25 to 50 per cent. Owing to this low power factor the motor will require 200 to 400 per cent normal kilovolt-amperes at starting if the load is appreciable. Since synchronous motors in general are of the larger sizes, the effect upon the generating system may be a serious consideration. In this connection Fig 3 is of interest. This is typical of a line of motors of about 150-kva. rating. It will be noted that the current-inrush values are much lower for slow-speed motors than for high-speed motors. For example, a 100-r.p.m. motor starting on 100 per cent voltage will have about the same kilovolt-ampere inrush as a 1,000-r.p.m. motor starting on a 60 per cent tap, as indicated by the dotted line. On the other hand, high-speed motors commonly have better starting characteristics and may consequently be started on lower voltages.

The operation of starting a self-starting synchronous motor is similar to the starting of an induction motor, but is somewhat more involved. In order to restrict the current inrush and to prevent too sudden impulse, reduced voltage is applied to the stator windings, and after the motor has reached synchronous speed, it is transferred to full voltage. The reduced starting voltage may be obtained from auto-transformers or taken from taps of the main transformers, if any, which supply the motor. It is usually desirable to apply in starting as low a voltage as will insure the necessary starting and pull-in torques, provided this voltage is not so low that the current peak when throwing to full voltage exceeds the initial inrush and provided acceleration is rapid enough to prevent overheating of the squirrel-cage winding.

Voltage Induced in Field Coils

When starting a synchronous motor from rest, an alternating flux passes through the field poles and causes to be induced in the field coils a rather high voltage. This voltage is high, owing to the comparatively large number of field turns in series. Obviously, it is higher if the fields are wound for 250-volt excitation than if 125-volt excitation be used. If the field coils are short-circuited during the starting period, a current flows in them and this current restricts the flux and the voltage generated thereby. On the other hand, the reaction of this current tends, to some extent, to reduce the static torque and may thus be undesirable. A compromise is usually made by short-circuiting the field coils through a fairly high resistance. This practice restricts the voltage induced, yet minimizes the detrimental influence on motor torque. When the motor approaches full speed, the torque due to the field reaction assists rather than opposes the main torque. As this action depends upon the resistance in circuit, it may be desirable to adjust this resistance for maximum running effect. This may be done by running the motor under load as an induction machine and adjusting the field short-circuiting resistance to give the higest attainable speed. Usually, the fields are short-circuited through the field discharge resistance, the field rheostat, the exciter, or a combination of these is used.

Three Methods of Starting

Three methods of starting synchronous motors are in common use. Each has its advocates, and it is probable that each has advantages for certain conditions. In one method the motor is started on reduced voltage. If the load is light, it may pull into step while on partial voltage and without direct-current field excitation. In such case it functions as a synchronous motor with excitation supplied from the alternating-current system. Ordinarily, some excitation must be applied to assist the motor in pulling into step. This excitation should be applied when the motor has attained about 95 per cent of synchronous speed and should be sufficient to insure that the motor pulls into step with a polarity relation corresponding to the excitation applied. It is usually well to apply excitation about corresponding to that giving unity power factor with no load and full voltage. If the motor pulls into step with this excitation, full voltage is applied.

Some motors tend to oscillate when excitation is ap-

plied and they pull into synchronism. Time must be allowed for the motor to become stable before transferring to full voltage, otherwise it may fall out of step. The current peak incident to the transfer operation is governed, to a marked extent, by the excitation applied. It is desirable that the excitation applied to pull the motor into synchronism on the low-voltage tap be such that the motor is considerably overexcited with reference to its load and partial voltage condition. It then draws considerable leading wattless current. When the motor is transferred to full voltage, it will be somewhat underexcited and will draw lagging current. If the motor were excited when running on low voltage, to an amount corresponding to its full voltage, full-load condition, it would be excessively overexcited with reference to partial voltage requirement and would draw a heavy leading current. A compromise is desirable between the leading wattless current taken on partial voltage and the lagging wattless current on full voltage.

Transfer from Reduced to Full Voltage

The transfer from reduced voltage to full voltage must be accomplished quickly lest the time interval be sufficient to permit the rotor to slip back a pole. If this happens, the generated countervoltage and the impressed stator voltage are cumulative and practically a short-circuit results, the current flow being limited only by the reactance in circuit. A similar shock may be produced by transferring to line voltage with the rotor in synchronism but of wrong polarity, owing to insufficient excitation to pull the rotor into proper polarity at reduced voltage.

If excitation be applied with the machine at rest, the magnetic circuit will be saturated, which will reduce the torque and increase the kilowatt-ampere input. Some additional surging will arise in the alternating-current line, and pulsations will be caused in the direct-current line. After the motor has started, a counter-torque will be developed due to excitation, and under some conditions this torque may prevent acceleration.

During the starting operation it is desirable to know when the motor approaches or attains synchronous speed. This is indicated by a field ammeter of the permanent-magnet type, which should always be included in the control equipment. While the motor speed is well below synchronism, the needle will vibrate owing to the rapid alternations of the current if the field circuit is closed through the discharge resistance. As the slip decreases, the rapidity of the pulsations decreases and the deflections increase. If the motor pulls into synchronism without excitation, the ammeter needle goes to zero. If direct-current excitation is applied before the motor pulls into step, the action is similar except that the needle does not return to zero, but becomes stationary and indicates the amount of excitation current applied.

There are also pulsations in the stator current while the motor is running below synchronism, these being more distinct as the slip decreases. These pulsations are due to the variation of reactance with differing relative positions of the rotor polepieces with respect to the stator poles. The stator current falls off markedly when the motor pulls into step. However, the field-circuit pulsations give the most distinct indication of the synchronous condition.

The sequence of operations, when starting and pulling into synchronism on reduced voltage, may be summarized as follows:

1. See that the field switch is closed to the position to connect the field coils through the proper resistance.
2. Close the switch to connect the motor to the starting voltage.
3. When the motor has accelerated to synchronism or nearly so, as indicated by the field ammeter, build up the exciter voltage, apply excitation and adjust to proper value. The motor should then pull into step.
4. Transfer quickly from starting to running voltage.
5. Adjust the field rheostat to running position.

If the starting load is heavy, the motor may not be able to accelerate, with reduced voltage, sufficiently close to synchronous speed to enable it to pull into step. It is therefore common practice, particularly in starting heavy loads, to connect the motor first to reduced voltage and then to transfer to full voltage before applying excitation. The excitation should be applied after the transfer to full voltage as the motor approaches synchronous speed. This method is simple and affords high pull-in torque. The current taken by the motor operating as an induction motor on full voltage under load may not always be permissible. There is also a possibility that, when excitation is applied, the relative positions of rotor and stator poles may be such that the rotor field momentarily bucks the stator field, until the rotor slips a pole. Under this condition a heavy current inrush will take place similar to that which occurs when two generators are thrown together out of phase. It was shown in Fig. 3 that low-speed synchronous motors have relatively high impedance so that, if connected directly to full voltage in starting, the current inrush will not be prohibitive—no greater, in fact, than the current inrush to a high-speed motor with reduced voltage. Thus it is feasible to accelerate motors of this class on full voltage, applying excitation when full speed is approached. This method has advantage of extreme simplicity and eliminates the transfer interruption and peak.

Automatic Controllers Available

Automatic controllers have been recently developed which will cause the various steps in the starting operation to be performed in sequence. The main circuits are handled by magnetic contactors. These may respond to suitable current-limiting and sequence relays in the motor circuits, or a pilot motor, driving a master switch, may be used, giving time element starting.

In a few instances synchronous motors are started by applying variable frequency supplied from a special motor-generator set. Good torques can be obtained in this manner if the generator and motor have low synchronous impedance and there is little reactance in the connecting lines. The principal advantage lies in the fact that the starting-current peak may be minimized as the demand on the main system is energy current only.

Where fairly heavy starting torques are to be handled or where it is desirable to minimize starting-current peaks, the practice is often followed to start the motor without load and to apply the load through a clutch or otherwise. In the case of pumps, fans and air compressors, valves, dampers or bypasses may be provided to minimize the starting requirement. Where clutches are used, they are usually of the magnetic type. With the scheme of starting previously described, where the stator is first brought up to synchronous speed and then gradually brought to rest while the rotor comes up to speed, loads can be started up to the pull-out torque of the motor without the use of a clutch.

Reminiscences of a Veteran Mechanical Engineer—I

Early Experiences in Learning the Principles of the Science of Steam Under Lieut. Charles E. Emery and William Wright

By W. H. ODELL

IN COMPARING the work of the machinist and engineer of the present day with that of the same class of men of the period of the War of the Rebellion and the following decades, I do not know how better to pay tribute to the pioneers of that time than to tell something of the character of the men I have had the

W. H. ODELL

pleasure as well as the honor of meeting and associating with, than to record the events that led up to such meetings, when friendships were formed that lasted through life.

At that time problems came up for the first time that had to be met and solved. There were no facilities then such as we have today, and the fact that such problems were met and solved is proof positive that there were giants, mentally as well as physically, at that time.

Having served a four-year apprenticeship at the machinist's trade in Brooklyn, N. Y., and with nothing but a country-school education, a rugged constitution and the further determination to be chief engineer of as fine a ship as sailed out of Sandy Hook within twelve years, I started in at the Old Morgan Iron Works at the foot of East Ninth Street, New York City.

At that time the superintendent of the works was Henry Mason. The war was on, and when I showed my apprenticeship papers, told him of my ambition and asked him to take me on under instructions for a year, he gave me a sharp look while his face took on a broad smile, and he replied: "We have no time to bother with anyone under instructions, but I will put you to work under the smartest gang boss we have in the works, and if you want to learn you will have the chance."

He put me to work under "Jim" Shawnessy, who at that time was gang boss on the "Fulton," a steamer with oscillating engines then being overhauled, and of which, if I remember the given name aright, Herman Winters was chief engineer.

Promotion to the Job of Gang Boss

Mr. Mason must have been satisfied with my work as he soon promoted me to gang boss, but as I look back over all the years and compare his kindly interest in his men with the "efficiency" men of today, I wonder if there are any superintendents left who would try to reach the hearts of his men as Mr. Mason did. Learning about this time that the Novelty Iron Works, at the foot of East Twelfth Street, was fitting out a fleet of steamers for the Pacific Mail Steamship Co., I obtained work there.

These steamers were "side-wheelers" and fitted with beam engines of 110-in. diameter cylinder by 12-ft. stroke, and as a comparison of the methods in use in the early 50's with those of the present day, I will state that the bedplates on which the jet condensers and cylinders rested were huge castings, the bearing surfaces of which had to be chipped, filed and scraped true by hand. This took a gang of men several weeks to finish, and it was while working with one of these gangs that the news reached us of the assassination of President Lincoln, for whom I had cast my first vote. There was no more work for our gang that day.

While at this works I met for the first time Lieut, Charles E. Emery of the U. S. Navy, who had been sent by the Treasury Department to conduct a series of tests on a Harrison sectional steam boiler. I was assigned as a workman to assist Mr. Emery, who made a place in his heart for me and taught me the first principles of the science of steam. The Richards indicator had not been brought out at this time, and we used the cumbersome McNault indicator, which did fairly good work up to fifty revolutions per minute. This was my first experience with the indicator, but I bought one of the Richards make the first time I saw one.

About this time I married, and when the first child came, I decided to give up the seas; and as the city was no place for me, I took a position as engineer of a mill, or rather factory, at Yonkers, N. Y., and while

manipulating my old McNault, or Novelty Iron Works indicator, one day, on a Woodruff & Beach engine, William Wright called with his sales agent, and I was brought in contact with another of the prominent engineers of that day, and my future decided upon.

We had four boilers in the fireroom of the factory at Yonkers, and about one-half the steam made was used on the engine and the other half in the dye house.

On the exhaust there was a small coil heater that merely took the chill off the feed water, while the rest was wasted. Live steam was used to heat the factory and the drips from the coils wasted through a Nason trap.

Using the Exhaust Steam

As by this time I had begun to realize the value of a heat unit, although I had never heard it called by that name, the thought came that if the boiler pressure was increased 10 lb., a back pressure could be put on the engine sufficient to enable the exhaust to be used for boiling the dye kettles. This was put up to the owner of the factory, and after much pleading the necessary changes were made. Also, a large open tank was purchased, in which the feed water was raised to near the boiling point by the surplus exhaust steam.

While these changes were being made, the annual inventory was taken, and about the same time the following year at the close of the inventory, one of the proprietors came in the engine room and said; "William, we are up against a stone wall and wonder if you can help us out. When you came here we were about buying an additional boiler. We have not bought that boiler, and last year we turned out about 12 per cent more goods than the previous year and have apparently used about six hundred tons less coal; now, how could we have have made such a mistake in our coal inventory?" The reply was: "You have made no mistake. This saving is due to making use of the heat in the exhaust steam, which you had been throwing away; also in reforming the methods of fixing the boilers and keeping the heating surface clean, as well as stopping many unnecessary leaks."

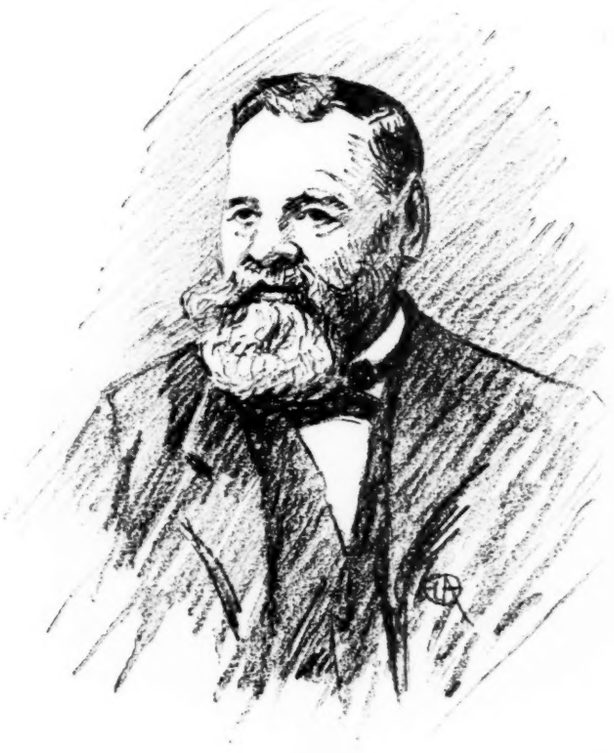
Of course, I was highly complimented and assured my efforts would be appreciated, and my good wife and I had arranged how we could use to best advantage the $500 check we hoped to get as a Christmas present; but when the holidays passed and no check came, I asked for a dollar a day raise in my wages and got it. Please note I say "wages," not "salary," and the moral of all this is that the workman should first show his employer he is worthy of increased compensation and then ask for it, otherwise he will most likely not get it.

I am quite positive this was the first time work of this nature was ever done, while today it is the common practice. What a change in a few brief years!

Meets William Wright

I have already said that it was at this plant I first met William Wright. This meeting was some four years after the changes previously noted had been made. The engine of which I was in charge was built by Woodruff & Beach at Hartford, Conn., while Mr. Wright was superintendent of boiler works; but I did not know this at the time, or in fact to whom I was talking. The inlet poppet valves of this engine were operated by a cam controlled by the governor which George H. Corliss claimed, as I learned later, was an infringement of the Corliss patents. Mr. Wright quizzed me as to how this cam was actuated, and when I explained, he wanted to know how I had found that out. The reply was, "Actuated by the inquiring spirit of an American citizen, as soon as I took charge I took it apart to find out," and to his further inquiry if I were not afraid I might not get it together again, the reply was, "Oh no! A regular machinist marks each piece with a prick punch before taking it apart." This seemed to please him immensely.

He was then conducted through the factory and shown how the changes had been made to use the exhaust



WILLIAM WRIGHT

steam, etc., and when he reached the engine room again he paid me a compliment that made me feel that life held something besides hard knocks; and he further said, "About all I can suggest to you is a larger engine, as this one is terribly overloaded as your diagrams show." At this point the salesman, who by the way had done most of the talking, broke in with a remark to the effect that Mr. Wright had taken over the old Washington Iron Works at Newburgh, N. Y., and gone into the stationary-engine business. I replied, "Is that so? I'm glad to learn that 'Bill' Wright has become his own employer." He then asked if I was acquainted with "Bill" Wright, as I called him. I replied, "No, but the draft riots in the city drove me out and I worked in the Washington Iron Works at the time he was superintendent of the works; and although I would not know him from a side of sole leather, all the boys always spoke of him as a man with a heart, and I am mightily pleased to learn of his success." The salesman immediately turned to Mr. Wright and said, "Mr. Wright, shake hands with an evidently unknown friend of yours!" As a young man I was credited by those who knew me well, with courage to face anything that came along, but the fact that I had been so rude as to refer

to such a man as Mr. Wright as "Bill" was wonderfully mortifying and was a lesson never to be forgotten.

However, it worked out all right, for a few days after this interview the same employer who four years previously had praised my efficiency, came to the engine room with a proposal to cut down my wages. Said a good man had offered to take the position at $21 a week, no pay for overtime, whereas they had paid nearly $2,000 the last year, much of which he admitted was for overtime. I replied, "Yes, but you have not only been saved the cost of a new boiler and the cost of the charges, but also more than it has cost for my service. The reply was, "That is a thing of the past, etc.," to which the reply was, "I think my services are worth $2,000 a year, and if I cannot earn it here I must look elsewhere."

Starting Out with the Indicator

I called immediately on Mr. Wright at Newburgh, who advised that I go out into the world and look for something a little better than a factory engineer's job. "Go to other factories," he advised, "and do for their owners what you have done at Yonkers." And he further assured me he would do all in his power to help me, and I believe he did. I accepted this advice, bought the requisite instruments and started in, my letterhead being "The Economical Generation and Application of Steam." How the changes have been rung on that heading as the years have passed!

I was soon approached by Professor Finn, editor of the *Technologist*, a trade paper of that day, who wanted me to write an article on the use of the indicator for his paper. This I did, and it was published in the September, 1874, issue. This I firmly believe was also the first article ever published in the technical press on this subject, and it was copied in a textbook issued about that time, which is now used in our colleges and (may I also say?) without credit to either author or publisher. In this article I had shown in dotted line a theoretical diagram and in full line a diagram I had taken from a George H. Corliss built engine. This cut was also used by a certain engine builder exhibiting at the Centennial in 1876, to illustrate the merits of his engine, but if it was copied from the original article or from the textbook, there is no means of knowing, as he also forgot to give credit to either author or publisher.

[In the second article of this series Mr. Odell takes up his association with Henry R. Worthington.—Editor.]

A New Type of Deep-Well Pump

A new type of deep-well pump (Axiflo) has recently been developed by the Worthington Pump & Machinery Corporation, operating on a principle heretofore not used in pumps of this kind. Although the pump is of the rotary class the water is not elevated by means of a conventional type of impeller, but a form of propeller is used similar to that employed for propelling ships.

The most radical departure in this pump is shown in Fig. 1. This is a section through a well casing and drop pipe. It illustrates one set of discharge vanes, the impeller, the shaft, the shaft coupling and the bearing.

In comparatively shallow wells one set of impellers might suffice, but in deep wells a number of impellers are necessary, these being placed one under the other, thereby making the pump equivalent to a two-stage, three-stage or other multi-stage pump.

Where it is desired or necessary to operate this pump by means of a horizontal motor, a steam engine, or by other means through a horizontal drive, a vertical pulley for belt driving may be placed on the head.

Where water must be elevated to a considerable height above the ground level, a centrifugal "booster pump" is added and connected to the pump shaft at the ground level. This combination gives a compact unit the same as would be ordinarily obtained by using two different pumps, one for deep-well pumping and the other for above-surface elevating. Fig. 2 shows this booster pump at the bottom with the discharge pipe emerging at the left. At the top is a standard vertical motor. Midway between the top and bottom is shown the housing for the thrust bearing.

The impellers are made of hard bronze, capable of withstanding the corrosive action of the usual well

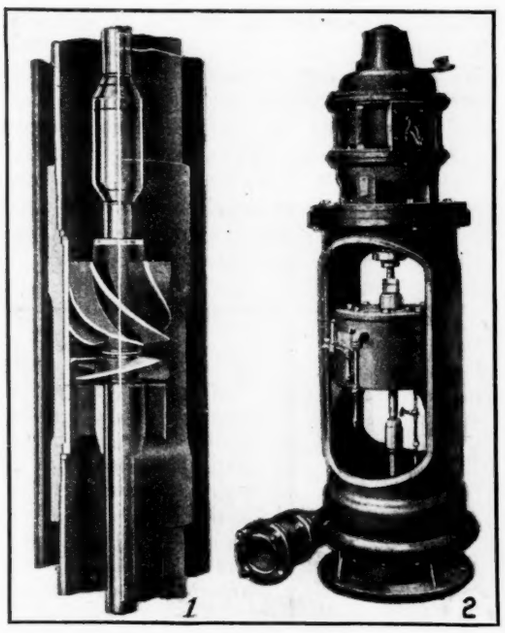


FIG. 1—ARRANGEMENT OF THE IMPELLER AND DISCHARGE VANES

FIG. 2—DIRECT MOTOR-DRIVEN HEAD, THRUST BEARING HOUSING, AND "BOOSTER" PUMP

water. The discharge vanes, clearly shown above the impeller in Fig. 1, receive water from the impeller and convert the velocity of flow into pressure and at the same time cause the water to flow upward smoothly along the axis of the pump. These vanes eliminate eddy currents and their accompanying waste.

The weight of the moving parts and the water-column thrust is taken up in a specially designed three-plate self-adjusting-type bearing that runs submerged in oil. The oil-bath is water-jacketed, a constant circulation of water being supplied by a small impeller attached to the pump shaft. The piping for water circulation is visible in Fig. 2. The self-aligning feature of this bearing and the fact that it runs submerged in a bath of water-cooled oil, materially reduce the attention required by the thrust bearing, the only requirement being the periodic filling of the thrust casing with oil.

Some of the principal advantages claimed for this type of pump by the manufacturer are: Double the capacity of any other type of deep-well pump from a given sized casing, excepting the air lift; three to six times the capacity of a two-plunger reciprocating pump of the same size of well; exceeds the capacity of a centrifugal pump by 15 to 75 per cent.

Steam-Turbine Governors and Valve Gears —Special Troubles of Hydraulic and Mechanical Types*

By EUSTIS H. THOMPSON†

THE majority of medium and large turbines are equipped with various forms of hydraulically operated gears. The governor actually operates the pilot valve only, which admits oil under pressure into an operating cylinder moving the piston, which in turn shifts the steam-valve stem. On small changes of load, the valve is moved but a slight amount, while for a large change the movement of the governor gives a larger pilot valve opening and the larger quantity of oil under a high pressure produces a quicker action in opening or closing the steam valve. Fig. 1 shows one form of such a valve gear which employs a floating or compensating lever, and Fig. 2 illustrates another form in which there is no compensating lever.

The detailed action of the compensating lever in providing a large valve opening for quick changes of load is indicated. Position *A*, Fig. 1, indicates the governor carrying a steady light load. Position *B* shows the governor immediately on slowing down due to a sudden increase of load. At position *C* the final adjustment of the valve gear is secured after the valve has moved to its proper position. It will be seen that in position *A* the pilot valve shuts off the oil flow to the hydraulic cylinder. In position *B* the movement of the governor produces a wide opening for the oil to flow into the top of the hydraulic cylinder and produce quick motion of the valve stem. The movement of the piston changes the compensating lever so that when the valve has taken its final position at *C*, the compensating lever, by moving upward, has shifted the pilot valve back to position *A* and shut off the circulation of oil.

In Fig. 2 appears another form of hydraulically operated valve mechanism. Here the flow of oil is more complicated as the main piston itself acts in the capacity of the oil-controlled piston. Arrows indicate the flow of oil. The dashpot, shown in Fig. 2, is for the purpose of exerting a steadying effect on the governor lever. Since the valve rod forms part of the pilot valve, there will be a slight tendency to cause the governor lever to move when this valve rod moves. This is due to the reaction of the oil on the differential areas of the governor rod and also to the friction between moving piston and rod. A little friction on the main lever is also desirable to prevent movement of the governor in response to small variations of the load. This has the effect of preventing overtraveling when the governor is compelled to make a quick movement in response to a sudden change of load. In this case the mass of the moving parts of the governor contains so much energy that when the valve reaches sufficient opening to check the change of speed, it has some tendency to move an undesirable distance beyond this correct point. The friction of the dashpot absorbs this inertia effect, and the valve is not inclined to overtravel as it would do in the absence of a dashpot. Many valve gears, however, operate quite successfully without dashpots.

Hunting may be caused by the same conditions as described for direct-connected valve gears in the previous article. In tracing out such troubles, the oil control of the gear must be considered. The pilot valve is the delicate part of this apparatus. There must be very little leakage of oil past this pilot valve, while it must operate without friction or binding. There are more points for lost motion. Possibilities of hydraulic valve gear trouble may be summarized as follows: (a) Friction; (b) lost motion; (c) oscillation; (d) poor regulation. Friction usually is found in the pilot valve and housing. This may be readily detected by disconnecting the governor link and moving the pilot valve by hand. The high spots on the valve stem or bushing should be eased off by scraping. Excessive diameters should be reduced in a lathe with emery cloth, being careful that the stem is thoroughly cleaned before reassembling. Friction of this kind is often excessive when a machine is first started up and improves greatly or disappears after the oil is warmed to running temperature. Friction, sticking or binding may occur in the steam valve or hydraulic piston, also in the governor parts.

CAUSES of hunting in auxiliary driven valve gears such as hydraulic, mechanical aud steam-cylinder types include those discussed in connection with direct-acting gears, with the addition of minor causes of pulsation peculiar to individual constructional features. Special adjustment is usually necessary in each type for smooth operation. Information of this character is obtained principally from the results of actual operation. Many readers could doubtless add much to this subject from their own experience. "Power" would be pleased to have such discussions for publication.

A dashpot, when employed in a valve gear is one of the most likely points for excessive friction to exist. If too heavy a grade of oil is used in the dashpot, hunting will be set up. When binding or sticking occurs on the plunger or rod, hunting or jerky motions may be produced in the valve gear.

Under the head of friction as a cause of hunting, it may be as well to state that lack of proper friction may also be a cause of hunting under some conditions. Valve gears with dashpots as in Fig. 2 may develop a slight surging action under certain conditions if the dashpot is disconnected or given too light a friction adjustment. This matter can easily be determined by trying adjust-

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ments on the dashpot at constant as well as widely varying loads. When too light a grade of oil is used, the effect of insufficient friction will be apparent, and adjustment of the bypass may show an improvement in operation, but will fail to give satisfactory operation.

In addition to the points of possible lost motion in the governor itself there exists the possibility of lost motion in the hydraulic piston-rod connections. This will produce a knocking in bad cases, while it may exist in such

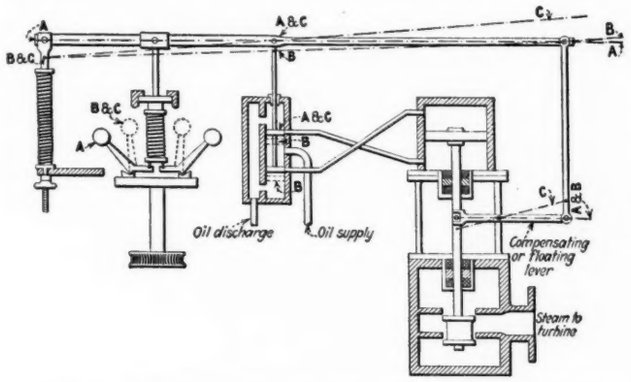


FIG. 1—COMPENSATING OR FLOATING LEVER ADJUSTS HYDRAULIC PISTON MOVEMENT

slight degree that it occurs only at long intervals, and at times produces in the valve stem a jerky motion which is communicated through the compensating device to the rest of the valve gear. This is sometimes difficult to locate, while other points of lost motion can readily be seen. It may occur only at intervals; a faltering movement of the gear may happen only when the turbine is started up from cold condition.

Hydraulic gears that are arranged to produce a continuous oscillation of the valve will be described later. The hydraulic gears at present under discussion have ordinarily a smooth motion.

Oscillations may be set up by defects of the hydraulic gear in addition to the causes described under direct-connected gears. Unbalanced pressures are sometimes set up in the pilot valve due to wear of an uneven character, to variable oil pressure, insufficient oil supply, or errors in manufacture such as excessive or insufficient lap of the valve.

Short Regulation and Excessive Mass

Abnormal conditions of short regulation, excessive mass or excessive steam admission cause surging as readily in hydraulic gears as in direct-connected gears. The excessive mass must exist ordinarily between and including the governor weight and the pilot valve. Excessive mass in that part of the gear which is moved by the hydraulic cylinder would never be expected as a cause of trouble in practice, on account of the greater reserve energy of the hydraulic piston, compared with the relatively small reserve of governor energy.

A great many steam-driven valve gears are at present in operation in which steam is supplied to the operating cylinder instead of oil. Such gears are subject to the same troubles as hydraulic gears, with addition of those peculiar to the use of steam.

Steam pilot valves will stick more readily and may require lubrication for proper action. The steam itself may contain impurities and therefore produce a sticking or binding action on both hydraulic gear and steam cylinder. The gear should be cleaned and lubricated at regular intervals. Should water come through with the steam it will naturally cause a hesitating action on the part of the valve gear. With proper piping and the exercise of care in starting up the turbine, there should be no trouble of this kind.

The pulsating hydraulic valve gear is used to a large extent. The use of the dashpot in this gear is fundamentally different from the application of the dashpot as shown in Fig. 2.

Scheme of Oscillating Type Gear

Fig. 3 shows the general working scheme of this gear, in which the pilot valve is given a constant oscillation. The steam valve or valves move up and down for a short distance with a regular reciprocating motion, except when closed. This assists in preventing the valve gear from sticking when one position of the governor is held for a long interval. The gear is always ready for a quick response to a change in speed.

The governor acts through the sleeve rod *A* to move the main governor lever *B* up or down in accordance with change of speed. This lever is pivoted at *C*. The link *E*, pivoted at *O*, is also moved in accordance with the governor, and its motion is transmitted to the pilot valve through link *D*, as indicated.

A reciprocating motion which is produced in the link *E*, by the rod *F*, is transferred in the same manner as the governor movements to the pilot valve. The

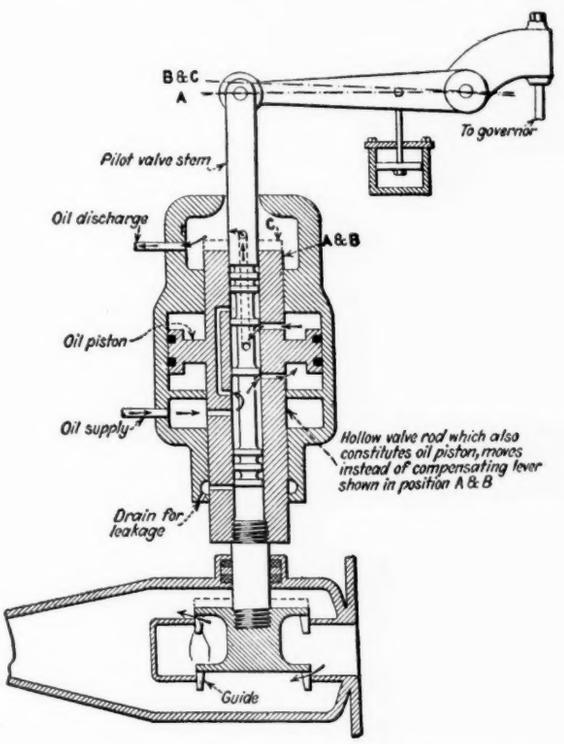


FIG. 2—OIL PISTON SUPPLIES COMPENSATING ACTION FOR HYDRAULIC GEAR

vertical rod *F* rises and falls with every revolution of the cam *G*, on which it contacts through a roller. If no dashpot were present, the main lever *B* would push up and down in the same way against the governor rod *A*. This would make the governor rod pulsate to some extent and therefore cause the flyballs to pulsate. In order to prevent these pulsations from reaching the governor, the dashpot *H* is connected to the

lever *B*. Each pulsation moves the dashpot plunger only a small amount, so that every little pulsation is transmitted to the governor rod *A*.

When a change of load occurs, the governor must move the main lever arm *B*. The governor, therefore, acts against the resistance of the dashpot. From this reasoning it is easily seen that the dashpot prevents oscillating movements of the governor lever due to the pulsations of the link *E* and yet it allows movements of the lever *B* in accordance with the pull of the governor.

Troubles that may be encountered in this gear are essentially the same as those of other hydraulic gears. Surging will be noticeable if the dashpot *H*, Fig. 3, is given too heavy a resistance, so as to slow down the movements of the governor. Trouble will also be encountered if the dashpot has too light a friction adjustment, in which case pulsations may be transmitted to the governor and the latter will tend to reciprocate in a period of its own and cause undesirable movements of the hydraulic piston or fail properly to follow speed changes.

Construction and Operation of Mechanical Valve Gear

A type of mechanical valve gear found on many turbines in operation, although no longer extensively manufactured, is shown in Fig. 4. With this design the turbine is supplied with a number of steam valves. Each of these valves is opened or closed by the engagement of pawls with the valve lifting head or crosshead. The pawls are mounted on a shaft that is moved up and down through the reciprocating action of the lever *C* and crank *L*. The cam *A* is under control of the governor. By the governor action the cam is raised or lowered to contact with the pawls. This determines whether the top or the bottom pawl operates, or neither one.

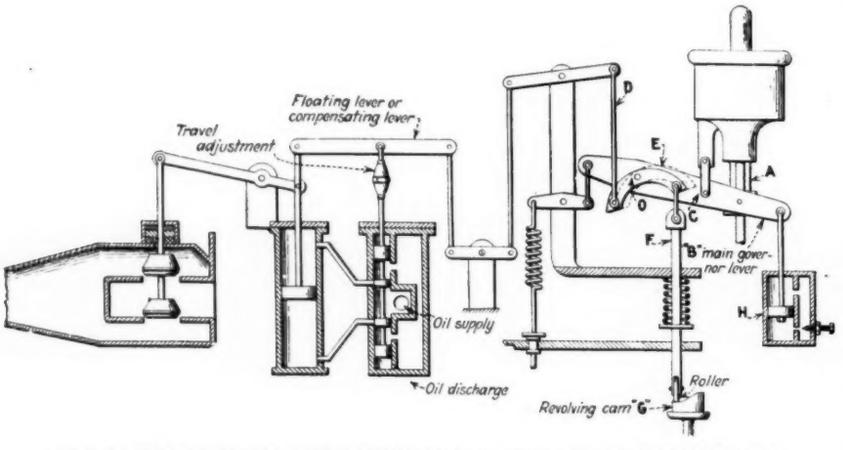


FIG. 3—OSCILLATING TYPE HYDRAULIC GEAR USES DASHPOT TO PREVENT OSCILLATIONS AFFECTING THE GOVERNOR

One valve and one cam together with operating pawls are shown in the section. When the cam at *A* moves up, the upper pawl is held away from the valve as shown, while the lower pawl is permitted to contact with the valve and therefore pushes the valve down and closes it on the downward stroke of the lever *C*. When *A* moves down, the pawl *B* will open the valve. In the neutral position of *A* no valve action will take place. The cams for the various valves are offset vertically as indicated at *F* at the bottom, so that the valves will not all work together, but rather they will close or open successively.

A regular pulsation is set up in the cam element by the fact that the upper pawl *B* rubs hard on the cam during the downward stroke of *C* and the lower pawl *A* actually clears the cam a little bit at the end of the downward stroke. This tends to make a downward push on each cam at each stroke of the lever *C*, whether the valve is opened or closed. During the upward stroke of *C* there is a similar condition which tends to push the cam element up. There is, therefore, a slight tendency to oscillate the cam element, and consequently the governor with which the cam element is connected. In order to prevent these oscillations, a dashpot is supplied with the cam element, shown at *F*. The dashpot plunger must be moved when the governor moves, but should contain sufficient friction to prevent oscillations of the valve gear from affecting the governor itself.

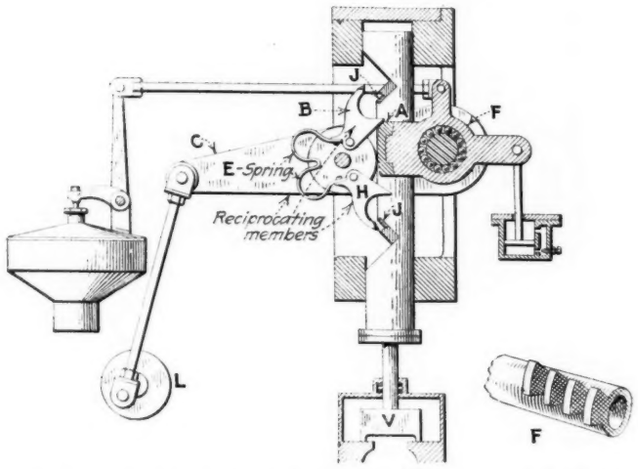


FIG. 4—DASHPOT OF MECHANICALLY DRIVEN GEAR REDUCES OSCILLATIONS THAT MAY ACT ON GOVERNOR

In addition to the troubles outlined in connection with direct-driven gears, hunting may be produced by excessive friction of the dashpot or by too light an adjustment of the dashpot. There are also troubles due to the various parts of the mechanical valve gear itself. Oscillations are more readily produced in the cam element when the springs at *E* are excessively strong. In such a case the cam element is struck harder and given a heavier rub by the pawls.

The length of the valve stem has a great deal to do with the smooth action of the valve. Valves as a rule close and open more smoothly when given a small clearance between the point of the upper pawl and the latch block *J* at the end of the upper stroke of *C*. A larger clearance is desirable from the bottom pawl to the lower latchblock, when the arm *C* is on its lower center. Too much clearance between the bottom pawl and latch may prevent the valve from closing properly, especially where the valve-rod packing is too tight. Excessive wear of bearings, pawls, or cams prevents satisfactory operation. Regular and thorough inspection is essential.

EDITORIALS

F. R. LOW, EDITOR

Waste-Heat Boilers for Gas Engines

APPROXIMATELY one-third of the heat input to a gas engine operating on blast-furnace gas is wasted in the sensible heat of the exhaust gases. About half of this heat may be recovered in the form of steam through the installation of suitable waste-heat boilers. A great many of the gas-engine plants of continental Europe are equipped with waste-heat boilers which, as an average performance, supply about two pounds of steam per brake horsepower developed by the engine.

There are installed in the United States and Canada about six hundred thousand horsepower of gas engines using blast-furnace gas. On the basis of an average output of one-third capacity over one and three-quarter billion brake horsepower hours are produced by these engines. If all these units were equipped with waste-heat boilers a total of over one and three-quarter million tons of steam yearly could be obtained by utilizing the heat of the exhaust. This would represent an equivalent of about two hundred and forty thousand tons of coal.

Inasmuch as the principal factor justifying the use of gas engines is their relatively high thermal economy, it would appear that the position of the gas engine might be materially strengthened through adoption of suitable means for waste-heat recovery.

Steam-Heating Fallacies

ONE frequently hears of cases where the engines or turbines of an isolated plant, with exhaust heating, are shut down and the boilers changed to low-pressure operation. Sometimes there is a perfectly good economic reason for this change, but as often as not certain common fallacies are the determining factors in the decision. Perhaps the most widely diffused of these is the belief, almost universally held by the non-technical public and sometimes by operating engineers as well, that it takes much more heat to produce a pound of steam at high pressure than at low pressure.

The facts are available to anyone who will take the trouble to inspect the steam tables. It will then be seen that a pound of steam at five pounds gage pressure contains 1,156 B.t.u., while at one hundred and fifty pounds gage, the heat content is 1,195 B.t.u. Assuming the feed-water temperature is two hundred degrees F., its heat content will be 168 B.t.u. The heat required to produce a pound of steam at five pounds pressure will then be 988 B.t.u. At one hundred and fifty pounds it will be 1,027 B.t.u., only four per cent more than five pounds.

There remains another closely related fallacy—one that is usually implied rather than stated. This is that since (or if) it requires much more heat to produce a given weight of high-pressure steam, it will require that much more coal to heat a building with high-pressure steam than with low. A little thought will show that this idea lacks even that grain of truth that lay in the first. Thermally, it makes no difference whether the steam contains much or little heat. In any case it requires a certain number of heat units per hour to warm a room or supply a given process. Whether the medium used for heating absorbs from the boiler a large or a small amount of heat per pound, it will give up the same amount in the radiator, so the boiler in any case must supply the amount of heat required to maintain the room at the desired temperature. Even if—as some people seem to imagine is the case—it required twice as much heat to produce a pound of high-pressure steam, and if this steam were supplied to the radiators at high pressure, the coal bill would not be increased. The only result would be that fewer pounds of steam would need to be supplied per hour.

Thermally, there is no reason why radiators should not be operated with high-pressure steam. It is not often done, because of the lower cost and greater simplicity of a low pressure heating system. A case that does occur frequently is that where the heating system is supplied from one or more of the following sources: The exhaust of prime movers; steam extracted from bleeder turbines; low-pressure steam obtained by passing part of the high-pressure steam output through a reducing valve.

As far as coal requirements are concerned, the third method is exactly equivalent to the direct use of low-pressure boilers for heating, since no heat is lost by the throttling process. It is a reasonable method of furnishing heating steam during periods when the supply of exhaust or bled steam is insufficient. All the steam passing through the reducing valve is produced and used as economically as with the low-pressure boiler plant, while any additional steam from which power is first produced represents a distinct gain on an energy basis over a straight low-pressure plant. The heat in the exhaust steam costs no more than usual, while the coal chargeable to power is only 10 to 20 per cent of that which a high-grade condensing plant would consume to produce the same amount of power.

Turning the Spot-Light on Lubrication

A GREATER interest in the development of facts concerning lubricants and lubrication should exist in the engineering profession in general and among operating engineers in particular. While it is true that certain theories about lubrication are pretty well established, it must be conceded that what is known is insignificant as compared with what ought to be known.

The operating man may say that this is not his work, that it is up to the oil refiners to find these things out and tell engineers about them. And so it is, but every suggestion that comes from the operating man or every kink that he locates and straightens out is going to help the work along, particularly if he comes out and tells about it.

Research covering bearings, steam cylinders, air-compressor cylinders, internal-combustion cylinders, ammonia-compressor cylinders and a thousand and one other types of equipment requiring lubricating oil and greases for the reduction of friction is seriously needed. Theoretically, the principles governing the lubrication of bearings have been pretty completely worked out. The difficulty in the practical application of these theories lies in the quantitative measurement of the various factors relating to such principles as found in every piece of mechanism. Here is where the operating and consulting engineer can aid the lubrication engineer by determining many of the conditions surrounding the operation of all kinds of equipment.

For instance, how many know the exact temperature or pressure to which the oil film is subjected in an ordinary, every-day lineshaft bearing? True, one may have a pretty good idea as to whether there is a complete film of oil supporting the shaft, but does anyone know how hot it actually is? If the speed is low or the load high, so that full film support does not exist, are the pressures the oil film is actually subjected to known? Suppose there are minute high spots which carry all the load, when the assumption is that it is evenly distributed over the entire bearing surface. What are the loads per square inch of surface and what happens when the oil carries such high pressures? Does the viscosity of the oil increase to prevent metallic contact, or does the high temperature so reduce the viscosity as to render the oil useless? What happens to surface tension, adhesion, cohesion, evaporation and perhaps many other properties under such conditions?

Then, too, operating engineers have had to contend with a certain amount of bunk passed along by oil salesmen, though not so much now as in the past, and it is hoped the future will see less and less of it as both engineers and salesmen learn more about oils and their application. Probably oil salesmen are not purposely dishonest when they tell things that are not true; they simply may not have had the opportunity to get complete information or perhaps have become confused as to what has been told them. Or they may not have been in touch with the more recent developments and may still be working along old lines.

The lubricating engineer must study oils more carefully, their make-up, their physical and chemical properties, how they vary with temperatures, pressures and so on. Many physical and chemical tests for measuring these properties have been standardized, so that at least they give comparative values, but there are still many fundamental properties about which we know little or nothing. Research is needed to develop methods of measuring these properties and determining their relationship to the problems of engineering.

Every lubrication engineer in his daily travels sees many examples of carelessness in handling and using oil. Barrels of oil are wasted through improper storage before they ever get to the machinery. And still more barrels are allowed to go to waste after passing over the bearings once, through not having proper means for collecting and reclaiming the oil for further use. It doesn't take a flood of oil to reduce friction and wear. A little, properly applied, will go a long way, give just as good results and will be less expensive in the long run. Every appliance and system worked out for the saving of oil should be considered as worth while from the viewpoint of money saved to the buyer and oil saved for future needs.

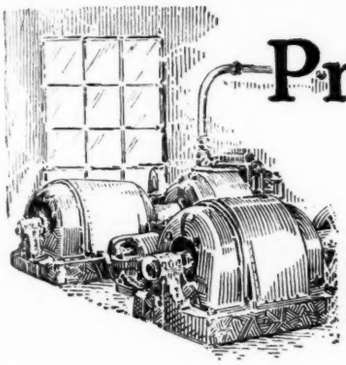
Water-Power Development Needs Co-operation

WITH the increasing cost of materials and labor the necessity of using more power and the introduction of improved processes to increase the productivity of labor is becoming more acute if this country is to compete in the world's markets and present standards of American living are to be maintained. One of the outstanding needs of the country is more power, available in larger units and distributed more widely and efficiently than ever before. The possibilities are much in evidence that a definite power-development plan of national if not of international proportions is working itself out at the present time. Comprehensive studies have already been made for such a plan. It would be little short of a national calamity should anything happen to prevent water power taking an economic place in this scheme.

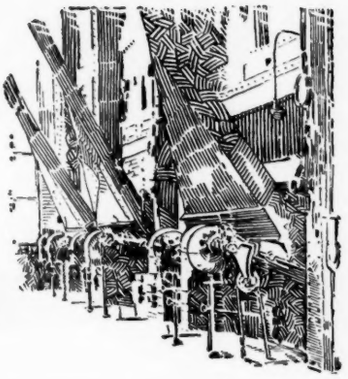
It may be safely said that water-power machinery has been developed to about as high an efficiency as can ever be expected. There will be refinements made in design, but much higher efficiencies cannot be expected. This makes it extremely important that water-power development be carried on along lines that will insure the most economic utilization. Any mistakes made by piecemeal developments cannot in the future be rectified and paid for out of gains in efficiency made in water-power machinery. Therefore, if our large water powers are to be utilized most economically, development must be on national and international lines and of a permanent nature.

Notwithstanding all this, the water-power developments are being retarded by all kinds of political complications, some states going so far as to place embargoes on the export of electrical energy from the state. Others again want no more developments made until they have time to make a complete survey of their water-power resources. Still others are blocking the way by a fight for state ownership or are attempting to enact legislation that will place undue restrictions on these developments.

One has only to review the effects of national legislation on water-power development to know how these developments may be retarded or encouraged. In the two and one-half years that the Federal Water-Power Act has been functioning, construction has been completed or started on projects aggregating a greater horsepower capacity than all those under government authorization before the passage of the act. The act has been wisely and liberally administered. Those who have had experience in water-power developments have been encouraged, while the speculator has been prevented from getting in. O. C. Merrill, Executive Secretary, Federal Water-Power Commission, speaking before the recent convention of the N.E.L.A. in New York, said: "We have in the Federal Water-Power Act a national policy determined only after years of deliberation, representing, if ever any legislation did, the matured judgment of Congress and the consensus of public opinion." The act has functioned in a way to unlock the doors that remained closed against water-power development for many years and has proved a genuine victory for true conservation. If the benefits of a national policy in water-power development are to endure, interstate jealousies and attempts to gain special privileges by restrictive legislation must be replaced by co-operation.



Practical Ideas *from* Practical Men



Pump Trouble and How It Was Cured

Some years ago the company with which I was connected took a contract for a complete power plant for a neighboring factory. A part of this plant consisted of a duplex steam pump of one of the standard makes, which was to draw water from a stream about three hundred feet distant, with about twelve feet lift, and force it into a tank on the roof of the factory, about sixty feet higher, this was to be the supply for the various needs of the establishment, amounting to about 30,000 gal. an hour.

In due course the plant was erected, steam raised in the boilers, and the pump started, in order to fill the tank. As soon as steam was turned on the pump piston gave a couple of kicks, as most empty pumps will, and then settled down to a strong steady pull.

Tom, the erector, was congratulating himself on the fine job he had made of that long suction line (for it had been talked around that the pump would not pull water through that long pipe) when word was brought to him that no water was going into the tank. He was sure the suction pipe was tight, as he had taken special pains with it, so he stopped the pump and took the whole water end apart, but could find nothing wrong, and after putting it together again and starting the pump, the result was as before.

So he reported to the shop, and another erector (who was considered the pump expert around the shop), was sent out to clear up the trouble. He went through the regular routine for all contrary pumps, but could find nothing wrong. It was finally decided to lift the end of the suction pipe out of the water, take off the foot valve, which might leak, screw a cap on the end of the pipe, fill the pipe with water, and apply pressure with a test pump. This was done and proved the pipe to be bottle-tight.

By this time the owners of the mill were getting impatient, as they could not run the factory without water, and they sent a letter to our office, and I was injected into the mess.

Of course I had to repeat all that had already been done, and do such new things as I could think of, like making sure of the gasket on the crossbar that separated the two ends of the valve chambers, looking for blowholes in the castings that would allow the water to circulate forward and backward from each end of the pump, but as far as I could see, everything was all right except that the thing would not pump water.

At last I concluded to try the effect of an air chamber on the suction line, without much hope that it would be of any benefit, but just to be doing something. The water end of the pump was provided with a suction opening on each side, the opening not in use being plugged. The plug was removed, a nipple with an elbow on one end was screwed in, and a vertical pipe four or five feet long screwed in the elbow. I closed the upper end of the pipe with a cap, making the whole of the same size as the suction pipe. It was a complete success, and we all went home happy.

Philadelphia, Pa. ALONZO G. COLLINS.

Abusing the Boiler

How often we read accounts of boilers being operated with the safety valve tied down or so piped up as to be useless, with plugged gage cocks or missing steam gages, not to mention bagged fire sheets and leaking joints, yet we do not hear of many explosions. How close to the danger point a boiler is operated and how much more it will stand than that for which it was designed is, I believe, a large question.

A few years ago an inspector in this district put his hammer through the shell of a return-tubular boiler that had been carrying 100 lb. pressure, yet it never showed the least signs of leaking. A small area had been eaten away but was still strong enough to stand the pressure. Some of the worst cases of abuse that I have ever seen have occurred to locomotive-type boilers.

One case was that of a locomotive-type boiler in a portable sawmill. The engine was mounted on top of the boiler and carrying 100 lb. pressure. When working under heavy loads the boiler would shake so hard that it would move on its foundation. One day the main belt broke, causing the engine to run away, breaking the flywheel and tipping the boiler over on its side, yet it did not explode, and as soon as the new wheel could be secured the boiler was righted and started up.

Another case was that of a railroad wreck at North Abington, Mass., a few months ago. A big piston-valve freight locomotive pulling about a dozen cars crashed head on into another train. In spite of the terrific strain to which the boiler was subjected and with a steam pressure of about 150 lb., there was no visible evidence of broken staybolts, sheared rivets or leaking seams.

I examined the certificate of inspection that I found in the cab, and according to it the safety valve was set to blow at 185 lb. and there was no fusible plug in the boiler. I believe that in freight engines this is the rule rather than the exception. This may be a surprise to some stationary men, but men in other branches of engineering sometimes do things to obtain results that are not considered good practice by central-station men.

Rockland, Mass. BURTON W. WHEELER.

Compressor Piston Springs a Leak

The machine shop of which I am foreman does general repairing of steam engines and ice machines. It was necessary in an emergency case to use an old ice-machine piston that had not been working for six months or more. We had it in a lathe and were boring a hole when suddenly there was a noise like the opening of a steam pipe. The lathe hand was burned and every man driven out of the shop.

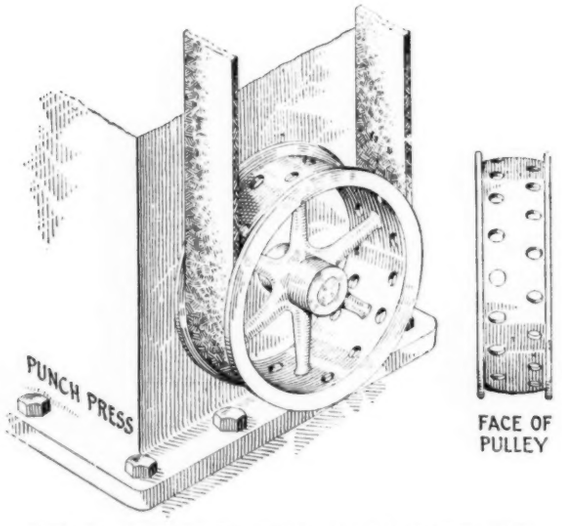
It seems that this casting was spongy and, in my opinion, ammonia must have forced its way into the piston and in time was sealed by deposits of oil, rust, etc., leaving full pressure on the ammonia. Drilling the hole allowed the ammonia liquid trapped in the piston to escape. I have often drilled or bored holes in ammonia pistons, but have never heard of anything like this. Every man engaged in such work should bear in mind the danger that may exist. F. DAWSON.

Jamaica, N. Y.

Drilled Holes in Pulley Prevent Belt Slippage

Belt slippage in most cases is due to overloading, and the best prevention is the substitution of adequate pulleys, or pulleys large enough to transmit the required effort. Under normal conditions the expense of this change is to be avoided. In consequence of this many remedies in the way of applied compounds of a resinous nature have been resorted to in an effort to avoid the slippage.

On a punch press in a local machine shop, slippage in the belt was a source of complaint and had a decided



HOLES IN FACE OF PULLEY INCREASES THE EFFECTIVE PULL

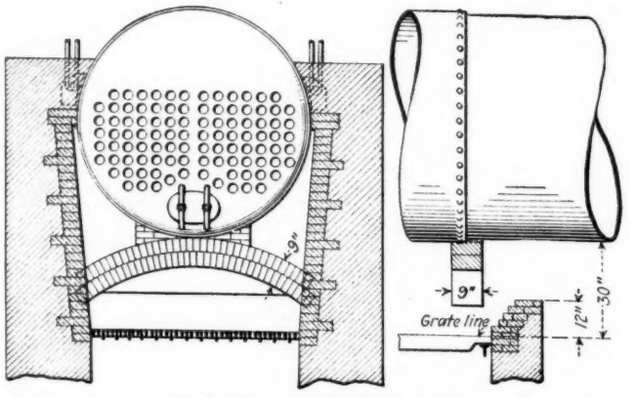
effect on the work of the machine. The usual compounds were tried, with more or less effective results; however, the final means adopted for preventing this trouble proved to be most effective. As shown in the illustration, a series of 1-in. holes were drilled around the face of the pulley, and the burr removed from the edge of each hole to protect the belt, and no other compound was used.

The reason the results are satisfactory is readily deduced from a consideration of the conditions. The drilled holes diminish the area of contact of the belt. In consequence of this, the belt pressure is increased for each unit of area, and as the pressure increases so does the coefficient of friction, resulting in increased effective pull. This method is simple and is correct enough in theory to warrant adoption in obstinate cases.

Washington, D.C. G. A. LUERS.

Brick Arch Prevents Girth-Seam Troubles

Several years ago I took charge of a plant in which there were two horizontal return-tubular boilers, 72 in. by 18 ft. These boilers were constructed of three rings of ½-in. plate. After they had been in operation a short



ARCH IS MADE OF TWO ROWS OF BRICKS AND PLACED DIRECTLY UNDER GIRTH SEAM

time, one of them developed fire cracks and began to leak at the girth seam. I had the rivets drawn and redriven, the cracks drilled and plugged and the seam chipped and calked, but had no success in making the joint tight; so finally, after trying a patch with no better results, I had a half-sheet applied with the girth seam about two feet beyond the bridge wall, which removed the seam to a point where the heat is less intense. We have had no trouble with leaks or fire cracks on this boiler since.

During 1920 the second boiler began to give trouble in the same way, and since to repair the boiler as I had the other one would have been an expensive job, I decided to try the brick arch, which I had been told would stop girth seam troubles. I had never had any experience with arches used in that way, so I got a mason to build an arch as shown in the illustration, in front of the bridge wall and directly under the girth seam, with the highest point of the arch just touching the boiler at the place where the trouble began. Then I had the space between the boiler and arch filled in for a distance of about sixteen inches each side of the center. Before the arch was started, I had a boilermaker clip and calk the joint until it was tight with cold water.

This boiler has been in service almost continuously since that time, and so far the trouble has not recurred. When the arch is about ready to fall down, we tear it out and rebuild it, but never fire the boiler without it. In our case the arch will last just about a year. As it takes less than one hundred firebrick, about a bag of clay and the services of a mason for three or four hours, it is an inexpensive and satisfactory repair, and I feel safe in recommending it to anyone who is having trouble of this nature. R. L. BEVIS.

Terre Haute, Ind.

Comments from Readers

What Caused the Freak CO_2 Readings?

I am interested from an analytical point of view in the article by M. S. Gerend in the May 8 issue, on "What Caused the Freak CO_2 Readings?"

The writer of the article invites discussion, but this necessitates further details of his operations. Gas sampling from an extremely hot area, as the first pass of any boiler, should be done by either non-oxidizable or water-cooled sampling tube. The cooling of the sample by saturated water, if direct cooling such as spraying or bubbling the samples through water, would introduce a source of error hardly within the operator's power to control.

The operation of the Orsat is simple enough when reasonable care is given to details, such as frequent renewal of solutions and checking with pure air provided the air sample is put through all three pipettes and the results are carefully observed. The pyrogallic solution ordinarily used for absorbing oxygen must not be made with KOH (caustic potash) purified by alcohol, as such a solution will generate CO, giving a false positive reading for oxygen and a false reading for CO. I do not understand the titration test by fractional normal KOH solutions using methyl orange indicator. All literature available and my experience indicate identical reaction of methyl orange with alkali hydrate and carbonate solutions.

I feel sure that a presentation of details as to sampling and analysis will reveal the source of the freak readings as described by Mr. Gerend. S. S. HEIDE.

Ensley, Ala.

Anyone caring to conduct the following simple experiment, can demonstrate the probable cause of these freak readings.

To make the experiment, I secured a 2-in. black pipe nipple 10 in. long and securely capped one end. This was packed with sawdust and the other end closed by a 2 to ¼ in. reducer and a ¼-in. pipe led to the rubber tubing of a hand gas analyzer. This analyzer uses KOH (caustic potash) solution as an absorbent and has a 50c.c. water-jacketed burette graduated to 21 per cent. After the instrument was connected, the nipple containing the sawdust was placed on a slow charcoal fire.

The gas was allowed to blow to the atmosphere for about five minutes, and a sample was then trapped in the analyzer and allowed to stand five minutes to cool and condense, then analyzed in the usual manner. The analysis showed an absorption far above the graduations on the instrument; this was estimated at about 50 per cent. This experiment was repeated several times with the same result each time.

From the foregoing it appears that about 50 per cent of the gas produced by the distillation of wood is readily absorbed by KOH solution. It is, therefore, probable that the gas being analyzed by Mr. Gerend was a mixture composed of the gases from combustion and from the distillation of wood.

The result of such an analysis would depend on the percentage of distillation gases in the mixture, but the presence of any of this gas would tend to increase the CO_2 reading. The low excess of air shown in the readings in question, supports this theory.

It is quite possible for excellent combustion to be taking place in one part of a furnace and at the same time a process of distillation in another part. As none of the furnace conditions are mentioned in the article in question, I assume this to be the cause when these readings were taken. E. C. THOMPSON.

Ooltewah, Tenn.

Utilizing Furnace Heat

Mr. Peebles' article in the May 22 issue, entitled "Combustion Control for Steam Boilers," makes it obvious that even with the most perfect control apparatus for draft and stoker speed, it is impossible, under the varying conditions of the fuel bed, to utilize the furnace temperature to the best advantage at all times. To accomplish this end it is necessary to go further and control other variables such as the boiler-feed supply. Heat storage by varying the water level in the boiler is receiving more consideration by engineers at this time, as it is recognized this is of prime importance in the saving of fuel.

European engineers, particularly, place a high value on the stored heat contained in the feed water for meeting peak loads. This is done by increasing the height of the water level during periods of light load, thus utilizing the high-temperature gases of the furnace and the lowering of stack temperatures. In this manner the boilers have a reserve water capacity, at a temperature due to pressure, which can be drawn upon to meet sudden peaks which occur before it is possible for the furnace to respond to the increase in the amount of fuel fed by the stoker and controlling apparatus.

The storing of water in boilers by means of varying the level performs the same function as a flywheel on an engine. It provides a balance or a reserve of power. The modern high-pressure boiler closely approaches that of the flash type. Consequently, it is most sensitive to changes in furnace temperatures, particularly at high ratings. Where a steady load exists, a uniform and continuous rate of flow of the feed water is no great problem with the modern continuous-flow type of feedwater regulator. This, however, is not sufficient where a variable load exists. The water input under this condition should not be in direct proportion but in inverse ratio to the steam output. The amount of variation that can be employed in the extremes of water levels is dependent on the particular type of boiler used. To secure the most effective results, the feed flow to the boilers must be at a definite rate for a given water level. If this is not the case, a correct relationship between water input and furnace temperature will not exist. C. E. WOLFF, JR.,

Erie, Pa. Northern Equipment Co.

Boiler-Furnace Design

I was much interested in Mr. Ricketts' paper on "Boiler Furnace Design," recently presented before the Metropolitan Section of the American Society of Mechanical Engineers and published in the April 17 issue. As the question of boiler-furnace design is becoming more and more important in large boilers operating at high capacities, the paper is both timely and valuable.

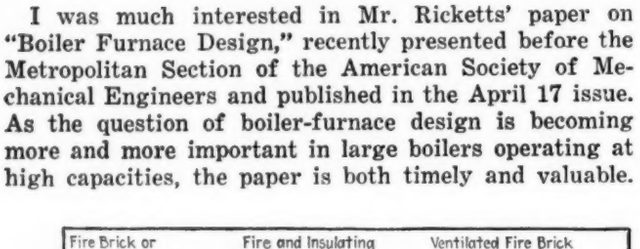

Fire Brick or Fire and Common Brick Construction
Fire and Insulating Brick Construction
Ventilated Fire Brick Wall Contruction
Duct
Transfer in B.T.U. per sq.ft. per hr.
Ash flow temperature
Penetration of ash flow temp.
Temperature, Degrees F.
Thickness of Walls in Inches

FIG. 1—EFFECT OF WALL CONSTRUCTION ON PENETRATION OF DANGEROUS TEMPERATURES

With the publication of this paper in *Power*, the results of the investigations by Mr. Ricketts and his associates have been made available for all engineers interested in this subject.

In view of the wide distribution of this paper, the following comments are made to discuss and interpret the facts in that part of the paper which deals with wall construction. Much has been said and written about ideal wall construction, but it is difficult today to make a general statement that will cover this subject completely. The ideal wall is one that will give the greatest economy when viewed from the standpoints of (1) low heat loss due to radiation, (2) low cost of construction and (3) long refractory lining life.

Attention is invited to Fig. 1 herewith (Fig. 5 of Mr. Ricketts' paper), in which the importance of proper wall insulation to boiler economy is clearly shown. The heat loss through the wall, which is composed of 9 in. of firebrick, 4½ in. of insulating brick and 8½ in. of red brick with a furnace temperature of 2,500 deg. F., is 310 B.t.u. per sq.ft. per hour; the total thickness of this wall is 22 in. With the wall composed of 13½ in. of firebrick and 9 in. of red brick, the heat loss with a furnace temperature of 2,500 deg. F. is 776 B.t.u. per sq.ft. per hour; this is with a wall thickness of 22½ in. The saving due to insulation is then 776 — 310 = 466 B.t.u. per sq.ft. of boiler wall per hour.

In order to bring these savings down to dollars and cents, a boiler with furnace dimensions has been assumed, and the return on the investment in insulation is computed as follows:

Assume boiler furnace 24 ft. wide, 20 ft. high and 14 ft. long. The total area through which heat radiates —side walls and front—equals $14 \times 20 \times 2 + 24 \times 20 = 1{,}040$ sq.ft.

Assume further that the boiler in the case operates 300 days a year, 24 hours a day on coal having a heat content of 13,500 B.t.u. a pound; coal valued at $6 a ton of 2,000 lb. on the grate, with a boiler efficiency of 75 per cent, the saving in B.t.u. per year equals $24 \times 300 \times 1{,}040 \times 446 = 3{,}489{,}408{,}000$.

Saving in tons of coal equals

$$\frac{3{,}489{,}408{,}000}{0.75 \times 13{,}500 \times 2{,}000} = 178.94$$

Dollars saved per year by insulation, $178.94 \times \$6 = \$1{,}073.64$.

In order to insulate one square foot of surface 4½ in. thick, 6.5 insulating brick would be required. The best insulating brick are 9x4½x2½-in., standard firebrick size. A certain number of red brick will be displaced by the insulating brick—the red brick are usually about 8x4x2-in., and 8.5 brick will be displaced per square foot by the use of insulation.

$1{,}040 \times 6.5 = 6{,}750$ insulating brick (9x4½x2½ in.).

$1{,}040 \times 8.5 = 8{,}850$ red brick (8x4x2 in.), displaced by insulating brick.

Figuring the cost of insulating brick at $100 a thousand on the ground, the gross investment in insulation in $6{,}750 \times \$100 = \$675$.

From the gross investment should be taken the value of the same number of red brick displaced together with the value of the additional red brick displaced, and the labor required to lay the additional red brick.

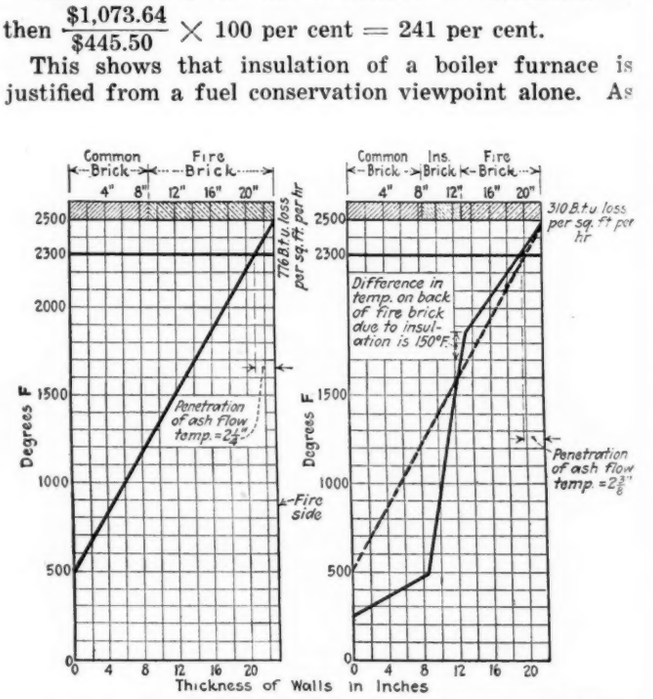
6,750 red brick at $20 a thousand with mortar = $135.

2,100 red brick at $45 a thousand with mortar and labor = $94.50.

Net investment in insulation $675.00 — $229.50 = $445.50.

The return on the net investment in insulation is, then $\frac{\$1{,}073.64}{\$445.50} \times 100$ per cent = 241 per cent.

This shows that insulation of a boiler furnace is justified from a fuel conservation viewpoint alone. As a matter of fact, complete insulation of a boiler setting between the firebrick and the red brick, or between the firebrick and the steel casing, is justified and is common practice. The insualtion of boiler tops with insulating brick is also widely practiced. (*The investment in insulation is returned within the first four months based on the figures in Mr. Ricketts' paper.*)


Common Brick
Fire Brick
Ins. Brick
776 B.t.u. loss per sq. ft. per hr
310 B.t.u. loss per sq. ft per hr
Difference in temp. on back of fire brick due to insulation is 150°F.
Penetration of ash flow temp. = 2⅜"
Penetration of ash flow temp. = 2⅞"
Fire side
Degrees F.
Thickness of Walls in Inches

FIGS. 2 AND 3—TEMPERATURE GRADIENT THROUGH NON-INSULATED AND INSULATED WALL

Fig. 2—Temperature gradient through non-insulated wall. Fig. 3—Temperature gradient through the two walls compared.

The penetration of dangerous temperatures in large

boilers operating at high capacities is almost wholly chargeable to regulation of pressure and draft, other factors being equal. Mr. Ricketts' paper shows that with a furnace temperature of 2,400 deg. F. and slight draft in the furnace, the wall temperature was 2,030 deg. F.; with 0.05 pressure the wall temperature was 2,300 deg. F; with 1 in. pressure the wall temperature rose to 2,380 deg. F. With a good grade of firebrick and a slight draft over the fire it may be assumed that little or no erosion of firebrick by molten ash occurs. The investigation by Mr. Ricketts and his associates also shows that little difficulty need be expected from straight fusion of the firebrick.

Fig. 3 shows the relationship between the use of insulation and the penetration of dangerous temperatures. This is somewhat different from the relationship shown in Fig. 1, assuming the same conditions.

Fig. 2 shows the temperature gradient through a wall composed of 13½-in. of firebrick and 9-in. of red brick, as used by Mr. Ricketts. As a matter of fact the temperature gradient from firebrick and red brick is not a straight line, but it may be considered so when used in connection with this discussion. The penetration of ash-flow temperatures is shown to be in this case, in Fig. 2, about 2¼ in.

Fig. 3 shows a wall similar to that shown by Mr. Ricketts in Fig. 1 herewith. This wall is composed of 9 in of firebrick, 4½ in. of insulating brick and 8½ in. of red brick. The temperature gradient through the insulated wall is shown in solid line, Fig. 3. The dotted line is temperature gradient through firebrick and red brick, Fig. 2, which has been superimposed to facilitate comparison of temperature gradient of Figs. 2 and 3. This shows plainly that there is an increase in temperature on the back of the firebrick of only 150 deg. F. due to insulation. It should always be remembered that the use of insulation does not affect conditions of draft or pressure within the furnace nor the temperature of the inner face of the firebrick. The penetration of ash-flow temperatures in the insulated walls is about 2⅜ in. This is practically the same as that shown for the solid firebrick and red brick construction.

The question of penetration of dangerous temperatures or the penetration of ash-flow temperatures is based almost entirely on theory, according to the writer's understanding of Mr. Ricketts' article.

In actual practice the insulated wall would probably have a longer life of refractory lining because with a given boiler producing a given amount of steam, the temperature in the insulated furnace will be less than the temperature in the uninsulated furnace. This would tend to increase the life of the lining.

Insulating brick can be practically and easily installed between the firebrick and the red brick in brick-set boilers, or between the firebrick and steel casing in steel-encased boilers. The proper thickness of refractory lining should always be allowed as a protection for the insulating brick. With the insulated wall construction shown in Fig. 3—namely, 9 in. of firebrick and 4½ in. of insulating brick and 8 in. of red brick in a boiler operating at high capacities—it would be highly desirable to use an insulating brick that would withstand a temperature of 2,000 to 2,100 deg. F. without change in character or size. This is a very important point.

A questionnaire sent recently to large public-utility plants in which insulation has been used for some time, revealed the fact that no difficulties had been experienced with the refractory lining due to insulation.

The total fuel savings made by the use of insulation runs to a large figure. The example cited herein shows briefly the importance of proper wall insulation.

Mr. Ricketts brings out the difficulties encountered when fireclay is used to lay up refractory lining in boilers operating at high capacities. By using a good grade of high-temperature cement, the danger of penetration of molten ash can be considerably reduced. In my opinion the use of high-temperature cement merits the consideration of every boiler engineer.

Where a pulverized-coal or forced-draft-stoker flame strikes the furnace wall, the effect of ash erosion is most pronounced. These flames carry small particles of molten ash which penetrate any cracks or pores in the brickwork. A good grade of high-temperature cement forms a definite bond between the firebrick and eliminates any danger of cracks which would allow the molten ash to get into the brickwork.

Based on the foregoing information the logical conclusion is that the ideal boiler wall is an insulated one regardless of whether it is brick-set or steel-encased.

East Orange, N. J. C. A. FRANKENHOFF.

"The Chief Took the Credit"

Many power-plant operatives, especially those of the old school, will bear a reminiscent smile as they read Mr. Summer's contribution in the May 29 issue entitled, "The Chief Took the Credit," and recall such instances where some unscrupulous "chief" appropriated their good stuff and had the deed for property recorded in his name.

I cannot refrain from citing an instance where the chief had removed some pins and bushings in a turbine governor, after which the governor would not function. He had worked several days trying to correct the trouble, when a helper suggested that the two links, which were identical in appearance, had been interchanged. The chief scoffed at the suggestion and accused the helper of presumption. The same evening, however, he returned to the plant and, secretly, as he thought, reversed the links. The next morning the turbine went into service O. K. and the chief called up the manager to apprise him that he had located and corrected the trouble, which was due to the primary valve sticking. He also "took the credit," but lost the respect of his men and five months later his resignation was requested.

It is gratifying to note that "chiefs" of this kind are rapidly becoming extinct. With a few possible exceptions, the chief of the modern power plant of today is too broad-minded to resort to any such petty thievery. His success depends largely on the development of an organization of men of whose skill and achievements he can proudly boast. DAVID CRAFT

Fairmount, W. Va.

Owing to a typographical error the size of the boilers at the River Rouge plant of the Ford Motor Co., as mentioned in "Data on Recent Industrial Plants," in the supplement to the May 29 issue, were given as 20,470 sq.ft. instead of 26,470 sq.ft. Moreover, the second section of the plant has just been completed, making eight boilers now installed instead of four.

Evolution is very slow! Heidelberg man used fire 25,000 to 100,000 years ago, but the modern man is still wasting fuel.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Form of Seat and Bearing Surface of Safety-Valve Disk

In specifications of safety valves what is meant by a valve 90 deg. to the center line of the spindle?

W. M.

The expression means to signify that the seat and bearing surface of valve disk are true planes or flat surfaces at right angles with the center line of the valve spindle, in place of being of conical form beveled to an angle of about 45 deg., as more commonly constructed.

Throwing Down a Brick Chimney

What would be a good method to "fall" a square brick chimney that is 6x6 ft. at the base, 3x3 ft. at the top and 65 ft. high, built of yellow sand brick about 30 years ago?

E. I. V. R.

About 4 ft. above the base opposite to the side toward which it is desired to have the chimney fall, cut out a mortar joint clear through the outside wall and lining and drive into the joint 10 or 12 equally spaced steel wedges, each about 3 in. wide and tapered about $\frac{3}{8}$ in. per foot. After all wedges have been inserted and driven up hard, at the same level, cut through the adjoining side walls nearly half way across from the side containing the wedges. Then, opposite to the wedges, cut away the side on which the chimney is to fall, making an opening about 3 ft. high, and alternately pick away the adjacent sides and drive up the wedges until the chimney topples over by hinging around the last brickwork left standing.

From unequal cutting and crumbling of the brickwork, the chimney in falling is likely to be slued to one side of the direction in which the fall may be expected and, for taking proper precautions against casualties, the job should be executed under the personal direction of one who is experienced in wrecking operations.

Heat Content of Steam Bled from Small Turbine

If dry saturated steam at 150 lb. gage pressure is supplied to a 150-hp. turbine, what would be the heat content per pound of steam bled from the first-stage exhaust at the pressure of 25 lb. gage?

R. N.

The initial steam supplied at the pressure of 150 lb. gage, or 165 lb. per sq.in. absolute, would contain 1,195 B.t.u. above 32 deg. F. By reference to a total-heat-entropy chart (the Mollier Diagram) for saturated and superheated steam, it may be seen that a pound of steam at the initial pressure 165 lb. per sq.in. absolute, when expanded adiabatically to the pressure of 25 lb. gage, or 40 lb. per sq.in. absolute (without loss of heat save in performance of work), would have a dryness of 91.6 per cent and heat content of 1,094 B.t.u. above 32 deg. F. However, this would be true only for perfect turbine efficiency and without allowance for the relatively small amount of heat lost by radiation. In the operation of a 150-hp. turbine the efficiency of the first stage would be about 75 per cent, and in place of utilizing 1,195 — 1,094 = 101 B.t.u. per pound of the initial steam, there would be conversion of 75 per cent of 101 = 75.75 B.t.u. per lb., leaving 1,195 — 75.75 = 1,119.25 B.t.u. per pound of the steam bled at the pressure of 25 lb., and the quality would be about 94 per cent dry.

Locomotive Type Boiler in Brick Setting

We have a locomotive-type heating boiler with 22 sq.ft. of shaking grate surface and sixty-four 3-in. flues and rated as suitable for 6,500 sq.ft. of radiation. The furnace gases pass through the flues, return under the shell and thence pass over the top of the shell to the chimney. The draft is fair, but the combustion appears to be imperfect, as the end flue sheet and all connections to the chimney have a 2-in. to 2½-in. coating of soot. The draft is controlled by a diaphragm regulator that operates the ashpit doors. Would there not be a saving of coal by a different form of setting and regulation of the draft with a stack damper?

L. C. H.

The type of setting can hardly be improved for this type of boiler. The principal advantage of regulating the draft by a stack damper would be to reduce loss of heat from leakage of air drawn into crevices and openings in the boiler setting at times when the full draft is not required. Soot deposits are unavoidable and consist mainly of incombustible material deposited as dust that is cemented together by moisture and unburnt hydrocarbons driven off the coal. The deposits are worse from undertaking to operate a boiler with thick fires and infrequent attention. There will be best fuel economy from running the boiler with a thin, clean fire, firing at frequent intervals, keeping the ashpit clean, and thoroughly cleaning the tubes and heating surfaces of scale and soot at least twice a month during the heating season. However, as little or no advantage is gained from the last passage of gases over the top of the shell, it is needless to clean the soot away from the top of the boiler except to insure sufficient draft area.

Induction Motor Flashes Over at Slip Rings

What causes a wound-rotor induction motor to flash over between winding and collector rings and between rings? The motor is used in forced-draft service, and the speed is controlled by drum controller with external resistance.

H. R. H.

The trouble may be due to either one of two causes or both. First, coal dust and moisture may have collected between the rings to a degree that allowed a flash-over at low voltage. On the other hand, the trouble may be caused by high voltage being induced in the secondary winding when the machine is shut down. If the rotor circuit is kept closed until after the stator is opened, when shutting the machine down, a current will be generated in the secondary winding that will neutralize all effects of wave distortion when the primary circuit is opened. However, if the secondary winding is opened before the primary, conditions can exist that will produce high voltage in the rotor winding. In opening the primary circuit, the current is supposed to follow the normal wave shape to zero when the arc is interruped and no further flux change has to take place; consequently, no over voltage is liable to occur. It has been found that owing to the cooling effect of the air or oil on the arc, the current is caused to die out much more quickly than the normal wave, and this has been shown by tests to cause peak voltage over four times normal peak value. Such voltages might easily cause flash-overs at the slip rings, especially when combined with the dirt that will collect on the windings and slip rings in a boiler room. It may be that the contacts on the controller have become burned or worn at the make-and-break ends, to a degree that allows the secondary circuit to open before the primary circuit opens. If the rotor winding is kept closed until after the primary is opened, there should be little danger of flash-over at the slip rings, under the conditions that the motor is operating.

Obtaining Hot Water from Exhaust Heater in Place of Condenser

For the operation of a knitting mill we have two return-tubular boilers that supply steam for water heating, for heating the buildings and for a 15x34-in. engine running 80 r.p.m. and operated condensing with a jet condenser. For processes we require daily about 60,000 gal. of water heated with live steam to about 200 deg. F. Most of this water is obtained from the condenser at 128 deg. F., and part of the condenser discharge water is used for boiler feed after it is passed through a closed feed-water heater placed between the engine and the condenser. Would it not be better to operate the engine non-condensing and perform all our water heating in an open exhaust-steam feed-water heater, large enough to condense all the steam, and do warming of the buildings with any excess of exhaust steam? A. D. K.

Development of the same power by the engine would abstract the same amount of heat whether the engine is operated condensing or non-condensing. The greater amount of heat contained in the exhaust when operating non-condensing would have to be supplied in the greater quantity of steam that would have to be handled by the engine, and consideration should be made of whether the engine cylinder is large enough for the purpose. The additional steam thus required would be the same in amount as the quantity of live steam now required to raise the temperature of the condenser discharge to the temperature that could be attained by raw water passed through an exhaust-steam heater. The only advantage would be greater convenience in obtaining process water of the desired temperature and saving of raw water now required for operation of the condenser at times when the condenser discharge is in excess of the quantity of water required for the processes.

In the operation of an exhaust-steam water heater, to prevent undue accumulation of back pressure, the exhaust must discharge to a condenser or provision must be made for its escape to the atmosphere for liberation of air and discharge of steam that may pass through the heater uncondensed. Any such discharge is wasteful unless entirely utilized in the heating system of the buildings, and reclamation of heat out of the exhaust would be of no greater economy than if the heating were performed by live steam obtained directly from the boiler in place of being first passed through the cylinder of the engine.

Formula for Use with Pitot

What is the formula for determining the velocity of water in a stream or pipe by means of a pitot tube? H. A. F.

Fig. 1 illustrates the water near the surface of an open stream flowing with the velocity V ft. per sec. and against the current is directed the opening of a pitot tube. The water rises in the tube to a height h ft.

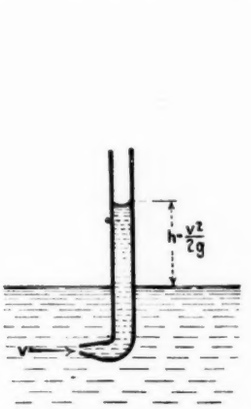


FIG. 1—PITOT TUBE USED IN OPEN STREAM

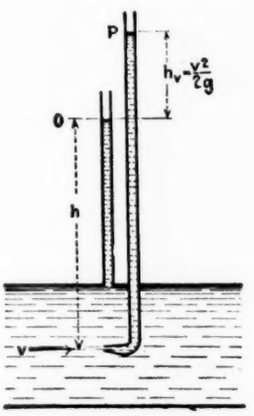


FIG. 2—PITOT TUBE USED IN PIPE LINE

above the surface of the stream, such that the velocity V, feet per second, would be attained by a body in falling by gravity through the height h, and therefore

$$V = \sqrt{2gh} \qquad (1)$$

where

V = Velocity of water received in impact against the tube opening;
g = Acceleration constant of gravity = 32.16;
h = Height in feet to which the water rises in the tube above the surface of the stream, or head corresponding to the velocity V ft. per second.

When a pitot tube is inserted in a pipe with the water flowing under pressure, as shown in Fig. 2, the water rises to a height P above the height O to which the water rises in an open column connected to a hole in the wall of the pipe. In that case the pitot tube shows the sum of the pressure head and the velocity head. Therefore the velocity is given by the formula,

$$V = \sqrt{2gh_v} \qquad (2)$$

where

V = Velocity of water in feet per second;
g = Acceleration constant of gravity = 32.16;
h_v = Velocity head or difference between the pressure head in the pipe and total head in the pitot tube.

Easy Lessons in Engineering

How to Use Logarithms

Logarithms were invented to save time and labor in computations. Their greatest usefulness is found in pure science and in certain branches of engineering (such as surveying) where many computations must be made to a high degree of accuracy.

Nevertheless, it should pay the power-plant engineer who is not familiar with logarithms to spend an hour or two of his time in mastering the fundamental principles.

With logarithms multiplication becomes addition, division becomes subtraction, raising to powers becomes multiplication and the taking of roots becomes division.

Our first step in learning to use logarithms is to understand how to read the accompanying table. This table is equivalent to two separate pages. On each page will be found a column of numbers on the left and a row across the top. The column gives the number to one decimal place, while the top row gives the second decimal place. All the other figures on the page are logarithms (or logs for short). To find the log of 2.36, look opposite 2.3 and under 6. The log, while written as 3729, is really 0.3729, it being understood that a decimal point precedes every log in the table. To make sure that he can read the table correctly the reader should look up the following logs in the table:

Number	Log
1.00	0.0000
9.63	0.9836
7.21	0.8579
3.20	0.5051

	0	1	2	3	4	5	6	7	8	9
1.0	0 0000	0043	0086	0128	0170	0212	0253	0294	0334	0374
1.1	0414	0453	0492	0531	0569	0607	0645	0682	0719	0755
1.2	0792	0828	0864	0899	0934	0969	1004	1038	1072	1106
1.3	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430
1.4	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732
1.5	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014
1.6	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279
1.7	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529
1.8	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765
1.9	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989
2.0	0.3010	3032	3054	3075	3096	3118	3139	3160	3181	3201
2.1	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404
2.2	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598
2.3	3617	3636	3655	3674	3692	3711	3729	3747	3766	3784
2.4	3802	3820	3838	3856	3874	3892	3909	3927	3945	3962
2.5	3979	3997	4014	4031	4048	4065	4082	4099	4116	4133
2.6	4150	4166	4183	4200	4216	4232	4249	4265	4281	4298
2.7	4314	4330	4346	4362	4378	4393	4409	4425	4440	4456
2.8	4472	4487	4502	4518	4533	4548	4564	4579	4594	4609
2.9	4624	4639	4654	4669	4683	4698	4713	4728	4742	4757
3.0	0.4771	4786	4800	4814	4829	4843	4857	4871	4886	4900
3.1	4914	4928	4942	4955	4969	4983	4997	5011	5024	5038
3.2	5051	5065	5079	5092	5105	5119	5132	5145	5159	5172
3.3	5185	5198	5211	5224	5237	5250	5263	5276	5289	5302
3.4	5315	5328	5340	5353	5366	5378	5391	5403	5416	5428
3.5	5441	5453	5465	5478	5490	5502	5514	5527	5539	5551
3.6	5563	5575	5587	5599	5611	5623	5635	5647	5658	5670
3.7	5682	5694	5705	5717	5729	5740	5752	5763	5775	5786
3.8	5798	5809	5821	5832	5843	5855	5866	5877	5888	5899
3.9	5911	5922	5933	5944	5955	5966	5977	5988	5999	6010
4.0	0.6021	6031	6042	6053	6064	6075	6085	6096	6107	6117
4.1	6128	6138	6149	6160	6170	6180	6191	6201	6212	6222
4.2	6232	6243	6253	6263	6274	6284	6294	6304	6314	6325
4.3	6335	6345	6355	6365	6375	6385	6395	6405	6415	6425
4.4	6435	6444	6454	6464	6474	6484	6493	6503	6513	6522
4.5	6532	6542	6551	6561	6571	6580	6590	6599	6609	6618
4.6	6628	6637	6646	6656	6665	6675	6684	6693	6702	6712
4.7	6721	6730	6739	6749	6758	6767	6776	6785	6794	6803
4.8	6812	6821	6830	6839	6848	6857	6866	6875	6884	6893
4.9	6902	6911	6920	6928	6937	6946	6955	6964	6972	6981
5 0	0.6990	6998	7007	7016	7024	7033	7042	7050	7059	7067
5.1	7076	7084	7093	7101	7110	7118	7126	7135	7143	7152
5.2	7160	7168	7177	7185	7193	7202	7210	7218	7226	7235
5.3	7243	7251	7259	7267	7275	7284	7292	7300	7308	7316
5.4	7324	7332	7340	7348	7356	7364	7372	7380	7388	7396
5.5	7404	7412	7419	7427	7435	7443	7451	7459	7466	7474
5.6	7482	7490	7497	7505	7513	7520	7528	7536	7543	7551
5.7	7559	7566	7574	7582	7589	7597	7604	7612	7619	7627
5.8	7634	7642	7649	7657	7664	7672	7679	7686	7694	7701
5.9	7709	7716	7723	7731	7738	7745	7752	7760	7767	7774
6.0	0 7782	7789	7796	7803	7810	7818	7825	7832	7839	7846
6.1	7853	7860	7868	7875	7882	7889	7896	7903	7910	7917
6.2	7924	7931	7938	7945	7952	7959	7966	7973	7980	7987
6.3	7993	8000	8007	8014	8021	8028	8035	8041	8048	8055
6.4	8062	8069	8075	8082	8089	8096	8102	8109	8116	8122
6.5	8129	8136	8142	8149	8156	8162	8169	8176	8182	8189
6.6	8195	8202	8209	8215	8222	8228	8235	8241	8248	8254
6.7	8261	8267	8274	8280	8287	8293	8299	8306	8312	8319
6.8	8325	8331	8338	8344	8351	8357	8363	8370	8376	8382
6.9	8388	8395	8401	8407	8414	8420	8426	8432	8439	8445
7.0	0.8451	8457	8463	8470	8476	8482	8488	8494	8500	8506
7.1	8513	8519	8525	8531	8537	8543	8549	8555	8561	8567
7.2	8573	8579	8585	8591	8597	8603	8609	8615	8621	8627
7.3	8633	8639	8645	8651	8657	8663	8669	8675	8681	8686
7.4	8692	8698	8704	8710	8716	8722	8727	8733	8739	8745
7.5	8751	8756	8762	8768	8774	8779	8785	8791	8797	8802
7.6	8808	8814	8820	8825	8831	8837	8842	8848	8854	8859
7.7	8865	8871	8876	8882	8887	8893	8899	8904	8910	8915
7.8	8921	8927	8932	8938	8943	8949	8954	8960	8965	8971
7.9	8976	8982	8987	8993	8998	9004	9009	9015	9020	9025
8.0	0.9031	9036	9042	9047	9053	9058	9063	9069	9074	9079
8.1	9085	9090	9096	9101	9106	9112	9117	9122	9128	9133
8.2	9138	9143	9149	9154	9159	9165	9170	9175	9180	9186
8.3	9191	9196	9201	9206	9212	9217	9222	9227	9232	9238
8.4	9243	9248	9253	9258	9263	9269	9274	9279	9284	9289
8.5	9294	9299	9304	9309	9315	9320	9325	9330	9335	9340
8.6	9345	9350	9355	9360	9365	9370	9375	9380	9385	9390
8.7	9395	9400	9405	9410	9415	9420	9425	9430	9435	9440
8.8	9445	9450	9455	9460	9465	9469	9474	9479	9484	9489
8.9	9494	9499	9504	9509	9513	9518	9523	9528	9533	9538
9.0	0.9542	9547	9552	9557	9562	9566	9571	9576	9581	9586
9.1	9590	9595	9600	9605	9609	9614	9619	9624	9628	9633
9.2	9638	9643	9647	9652	9657	9661	9666	9671	9675	9680
9.3	9685	9689	9694	9699	9703	9708	9713	9717	9722	9727
9.4	9731	9736	9741	9745	9750	9754	9759	9763	9768	9773
9.5	9777	9782	9786	9791	9795	9800	9805	9809	9814	9818
9.6	9823	9827	9832	9836	9841	9845	9850	9854	9859	9863
9.7	9868	9872	9877	9881	9886	9890	9894	9899	9903	9908
9.8	9912	9917	9921	9926	9930	9934	9939	9943	9948	9952
9.9	9956	9961	9965	9969	9974	9978	9983	9987	9991	9996

Then he should practice the reverse process by finding the numbers corresponding to certain logs, as shown in the following table:

Log	Number
0.6085	4.06
0.4771	3.00
0.5551	3.59
0.9983	9.96

It will be noticed that the logs in the table start at zero for 1.00 and steadily approach 1.0000 as the number approaches 10. The log of 10 is not given in the table, but it is exactly 1.0000. The number nearest to 10 in the table is 9.99, whose log is 0.9996, just under 1.0000.

The first operation that can be performed with logs is multiplication. This becomes simple addition. The rule is: *To multiply add the logs. The result is the log of the product.*

Suppose the problem is to multiply 1.25 by 7.80. The log of 1.25 is 0.0969 and that of 7.80 is 0.8921. The sum of 0.0969 and 0.8921 is 0.9890. This must be the log of the product. The table shows that the number whose log is 0.9890 is 9.75, so we see that $1.25 \times 7.80 = 9.75$. A more systematic way to write down this problem would be as follows:

Number		Log
1.25		0.0969
× 7.80		+ 0.8921
= 9.75	(Answer.)	= 0.9890

Next comes division, for which the rule is: *To divide, subtract the logs. The result is the log of the answer (or quotient).* To divide 5.25 by 4.20, proceed as follows:

Number		Log
5.25		0.7202
÷ 4.20		— 0.6232
= 1.25+	(Answer.)	= 0.0970

Here we seem to have made a slight error because it may be proved by arithmetic that the answer should be exactly 1.25, not 1.25+. But the log of 1.25 is given in the table as 0.0969, so we have had to write 1.25+ as the number whose log is 0.0970. This simply shows that logs are not absolutely exact. The four-place logs here used should, however, give answers correct to four places of figures, which is close enough for most work. Five-place and six-place logs, such as may be found in the reference books, will give answers correct to five and six places respectively.

Next comes powers. The rule is: *To raise a number to a power, multiply the log by the index of the power. The result is the log of the answer.* The following is the solution of the problem, $2.63^{1.42} = ?$:

Number		Log
2.63		0.4200
		× 1.42
3.948	(Answer.)	= 0.5964

Here the log, 0.5964, did not occur in the table, but was found to lie between 0.5955, which is the log of 3.94, and 0.5966, the log of 3.95. It was therefore evident that the correct answer lay between 3.94 and 3.95. The final answer, 3.948, was found by "interpolating," a process explained in the article on page 574 of the April 10 issue. Hereafter this interpolation will be used where necessary without further explanation.

The rule for taking roots is as follows: *To extract a root, divide the log of the number by the index of the root. The result is the log of the root.* For example, the cube root of 9.23 may be extracted as follows:

Number		Log
9.23		0.9652
		÷ 3
2.098	(Answer.)	= 0.3217

So far all the problems have been carefully selected so that both the numbers involved and the answers fell within the limits of the table, that is, between 1 and 10. The same table can be used for numbers greater than 10 or less than 1 by making slight changes, as will be now explained.

Any number outside the range from 1 to 10 is equal to one within these limits multiplied or divided by 10, 100, 1,000 or some other power of 10. This is shown by the following examples:

26.2	= 2.62 × 10
0.0596	= 5.96 ÷ 100
43,700	= 4.37 × 10,000
0.00150	= 1.50 ÷ 1,000

So the log of 26.2 must be the log of 2.62 (from the table) plus the log of 10. In the same way the log of 0.0596 is the log of 5.96 minus the log of 100. Now no table is needed for the logs of 10, 100, 1,000, etc. In each case the log is equal to the number of ciphers; the log of 10 is 1, of 100 is 2, of 1,000 is 3 and so on. Therefore the log of 26.2 = log 2.62 + log 10 = 0.4183 + 1 = 1.4183. In the same way the log of 0.0596 = log 5.96 — log 100 = 0.7752 — 2.00 = — 1.2248.

This last operation involved the algebraic sum of a positive and a negative quantity. If the reader does not understand how to take algebraic sums and differences, he should refer to the article on page 612 of the April 17 issue.

We now know how to get the log of any number, so all that is needed is a little practice in applying to various problems the rules already given. The following is the solution of the problem $7{,}910 \times 0.032 = ?$:

Number		Log	
7,910		0.8982 + 3 =	3.8982
× 0.032		0.5051 — 2 =	—1.4949
= 253.1	(Answer.)	Algebraic sum =	+ 2.4033

Here we found that 0.4033 was the log of 2.531. Knowing that 2. was the log of 100, we then saw that 2.4033 was the log of $2.531 \times 100 = 253.1$ A problem in division $0.672 \div 932.6 = ?$, is handled as follows:

Number		Log	
0.672		0.8274 — 1 =	—0.1726
÷ 932.6		0.9697 + 2 =	+ 2.9697
= 0.0007207	(Answer.)	Algebraic difference =	—3.1423 = + 0.8577 — 4

Here the algebraic difference of the logs came out negative, and had to be written as a positive decimal with a negative whole number before the log could be looked up in the table, which gives only positive decimal logs. Next, to raise 29.2 to the 2.3 power, proceed as follows:

Number		Log	
29.2		0.4654 + 1 =	+ 1.4654
			× 2.3
2,346	(Answer.)		= + 3.3704

As another problem the 1.7 root of 0.00563 may be extracted as follows:

Number		Log	
0.00563		0.7505 — 3 =	—2.2495
			÷ 1.7
0.04751			= —1.3232 = + 0.6768 — 2

Interpretations of the A. S. M. E. Boiler Code

REQUESTS for interpretations of the Boiler Code are acted upon by the Boiler Committee, their formulated replies being submitted to the Council of the American Society of Mechanical Engineers. The inquiries and replies are published from time to time in *Power*, with such explanatory comments and illustrations as seem advisable for a clear understanding of the interpretations on the part of engineers in general. The last group of interpretations published in *Power* was in the issue of Dec. 12, 1922.

Case No. 408—Inquiry: What thickness is required under Par. M-3 of the Code for Miniature Boilers for the plate forming heads which are not an integral part of the boiler? The thickness for heads which have riveted construction is not definitely specified in this paragraph.

Reply: It is the opinion of the Boiler Code Committee that the term "riveted shells" in the first sentence of this paragraph is intended to cover heads, in case they are not used as tube sheets.

Paragraph M-3 follows: Steel plates when used for any part of a miniature boiler, where under pressure, shall be of the firebox or flange grades, but in no case shall steel of less than ¼-in. thickness be used for riveted shells, or less than $\frac{5}{16}$-in. thickness for seamless shells. The heads, if used as tube sheets with tubes rolled in, shall be at least $\frac{5}{16}$ in. thick.

Case No. 409—Inquiry: Is it permissible, under Par. M-11 of the Code for Miniature Boilers, to weld on to the shell a half coupling for the reinforcement to give the necessary four full threads?

Reply: It is the opinion of the committee that the reinforcing may be accomplished only by a riveted pad or its equivalent, or by building up the thickness of the plate by welding, and that the welding of the half coupling on the outside of the plate is not permissible under this requirement.

Paragraph M-11 provides that all threaded openings in the boiler shell shall be provided with a riveted or welded reinforcement, if necessary, to give four full threads therein.

Case No. 410—Inquiry: Is it the intent of Par. M-16 of the Code for Miniature Boilers, that non-ferrous metal shall be used for the valve seat and also that the lifting device shall be of non-ferrous metal, as are required by Pars. 282 and 283 of the Power Boiler Section of the Code?

Reply: Attention is called to the fact that where the Rules of the Code for Miniature Boilers do not apply, those as above referred to in the Power Boiler Section of the Code are applicable.

Case 410—Paragraph M-16 specifies the use of a spring-loaded pop safety valve (at least ½ in. in diameter) connected directly to the boiler and having a relieving capacity of at least 3 lb. per hour per square foot of boiler-heating surface. It does not further specify the construction of this valve. The ruling, therefore, requires that paragraphs 282 and 283 of the Power Boiler section of the Code, be followed. These read as follows: Paragraph 282—"To insure the valve being free, each safety valve shall have a substantial lifting device by which the valve may be raised from its seat at least $\frac{1}{16}$ in. when there is no pressure on the boiler." Paragraph 283—"The seat and disks of safety valves shall be of non-ferrous material. The seat of the safety valve shall be fastened to the body of the valve in such a way that there is no possibility of the seat lifting."

Case No. 411—Inquiry: Par. 212*c* which permitted increasing the pitch of staybolts on cylindrical surfaces over that required for flat plates, had, about two years ago, been held in abeyance pending the revision of the Boiler Code, but nothing has been left in its place. In view of this, what rules should be followed pending the publication of the revised Code?

Reply: It has been proposed to revise Par. 212*c* as follows, and the committee recommends to the state inspectors that this rule be followed in place of the rules now given in Par. 212*c* of the Code:

Par. 212: *d*. For furnaces over 38 in. in outside diameter of vertical fire-tube boilers and other types of furnaces and combustion chambers not covered by special rules in this Code, which have curved sheets subject to external pressure, that is, pressure on the convex side, the staying, both circumferential and longitudinal, shall be provided for in accordance with the following formula:

$$P = \frac{CT^2}{p^2} \div 250\,\frac{R}{T}$$

where p and the value of C are as given in Par. 199, p shall not exceed $2T$, and p^2 shall not exceed $0.008\,CTR$.

The stress per square inch in staybolts shall not exceed 7,500 lb., based on a total stress obtained by multiplying the product of the circumferential and longitudinal pitches by $\left(P - 250\,\frac{R}{T}\right)$.

The letters in the preceding formula have the following meaning:

p = maximum pitch measured between straight lines passing through the centers of the staybolts in the different rows, which lines may be horizontal, vertical or inclined, in.
P = maximum allowable working pressure, lb. per sq.in.
R = internal radius of furnace, in.
T = thickness of plate in *sixteenths* of an inch.
C is a constant having the following values (from Par. 199): 112 for stays screwed through plates not over $\frac{7}{16}$ in. thick, with ends riveted over; 120 for stays screwed through plates over $\frac{7}{16}$ in. thick, with ends riveted over; 135 for stays screwed through plates and fitted with single nuts outside of plate; 150 for stays with heads not less than 1.3 times the diameter of the stays, screwed through plates or made a taper fit and having the heads formed on the stays before installing them and not riveted over, said heads being made to have a true bearing on the plate; 175 for stays fitted with inside and outside nuts and outside washers where the diameter of the washers is not less than $0.4\,p$ and the thickness is not less than T.

Case No. 412—Inquiry: Is it permissible, under the Code, to use on boilers, pressed-steel nozzles having the upper or bolting flange of the Vanstone joint construction, with the bolt flange made of steel?

Reply: While the form of construction proposed for a boiler nozzle embodying the use of the Vanstone joint, as outlined, does not conflict with the requirements of the Code, provided the flange dimensions, etc., meet the requirements of the Code for pipe flanges, it is the opinion of the Boiler Code Committee that a rigidly attached form of nozzle flange is preferable.

Case No. 413—Inquiry: What is the permissible stress for screwed stays with ends riveted over less than 20 diameters in length, when such screwed stays are inserted in the sheets at an angle that is not truly radial in the case of curved plates, or in the case of flat plates is not normal to the plane of the plate?

Reply: It is impossible to formulate any logical requirement for a condition of that sort and must be a matter of judgment. A revision of the Code has been proposed which reads as follows: "All staybolts not normal to the stayed surface shall have not less than three engaging threads, of which at least one shall be a full thread." The angularity in such case should not exceed 15 deg. to the stayed sheet. If the angularity is greater than 15 deg., it must be taken into account in calculating the permissible stress in the staybolt.

Case No. 414—(In the hands of the Committee).

Case No. 415—Inquiry: Where a boiler of the locomotive type is fitted with a form of removable drum, attached by bolted connection to the outlet nozzle, as is customary practice in the California oil fields, is it the intent of the Code that the requirements of Par. 194 shall apply to the construction of the drum, or can this construction be considered as a steam drum subject to the requirements of Par. 187?

Reply: It is the opinion of the Boiler Code Committee that the form of construction shown is not a boiler dome and therefore does not come under the requirements of Par. 194 of the Code, but must be considered as a steam boiler drum coming under the provisions of Pars. 187 and 188.

Paragraphs 187 and 188 require that where the drum has a greater diameter than 36 in. the longitudinal riveted joint shall be of butt-and-double-strap construction, but that such joints may be of lap-riveted construction provided the diameter of the drum is not over 36 in. and the pressure does not exceed 100 lb.

Case No. 416. (In the hands of the Committee.)

Case No. 417—Inquiry: Is it the intent of the Code to require any particular design for suspension lugs to support horizontal return-tubular boilers 78 in. or less in diameters?

Reply: It is the opinion of the committee that it was not the intent of the Code to require any particular design for suspension lugs to support horizontal return-tubular boilers 78 in. or less in diameter, but that any such lugs should conform to the requirements of Pars. 324 and 325 of the Code.

Industrial Heating Discussed

Industrial electrical heating as a source of profitable business for the central stations was the principal theme at the May 6 meeting of the Commercial National Section, N.E.L.A. In this connection the printed report of the Power Sales Bureau of the Section was the subject of much favorable comment. This outlined a comprehensive sales plan for obtaining industrial heating load. One of the important features of this plan was the holding of classes, under the auspices of the appliance manufacturers, to train the sales personnel in the technique of this field. A valuable feature of the report was a directory of manufacturers and users of industrial electrical heating apparatus. In the case of the users, the directory gave the kind of apparatus and its kilowatt capacity.

A subcommittee appointed to collect data on the operating costs of small isolated plants reported that such data were difficult to get, so that little progress had been made. The work is to be continued, paying particular attention to the Diesel and unaflow engines.

A short address on superpower was given by W. S. Murray, under whose direction the superpower report was prepared several years ago. He divided the history of the electrical industry into four periods. First, in the early days came the small company with its own small territory to which it sold power. In the second period several small companies formed a small group. At the same time larger stations were built to handle the steadily increasing loads. The third period was one of continued expansion of these groups accompanied by still further enlargement of power plants and by the interchange of power. The fourth period, according to Mr. Murray, will be characterized by the formation of the superpower zone in which all the central stations will be part of a single interconnected system. This will require the closest co-operation among the various public-utility companies.

The district covered by the superpower survey extends from Boston to Washington and 160 miles west from the coast. While this region is but 2 per cent of the area of the United States, it contains 25 per cent of the population.

Superpower, said Mr. Murray, finds its chief argument in the matter of load factor. By connecting up diversified power sources on the one hand and diversified consumers on the other, it should be possible to secure a great improvement in load factor. The result should be a marked decrease in the cost of power. Mr. Murray estimated that by 1930 the plant capacity in the superpower region would total 10,000,000 kw. Of this amount, water power cannot furnish more than 20 per cent. The remaining 80 per cent must necessarily come from steam plants. The importance of continued improvement in steam-plant efficiency is obvious. According to Mr. Murray the single feature of interconnection would affect a yearly saving of $230,000,000 in the Eastern superpower zone by 1930.

He recommended closer co-operation between the electrical utilities and the railroads. A heavy railroad load would improve the diversity factor. Moreover, a low rate to the railroads would reduce transportation costs and help business generally.

The discussion of industrial electrical heating showed a general agreement that this load would in ten years greatly exceed the industrial-motor load and probably the lighting load as well. It was the general opinion that care should be used to restrict sales effort to those applications where electric heating had a distinct advantage over combustion heating. The much higher cost of electric heat per B.t.u. must be counterbalanced by more efficient utilization or by better product, larger output, etc. The present connected industrial heating load in the United States amounts to about 1,200,000 kw.

It was stated that reports were being prepared covering the possibilities of electrification in various industries including pulp and paper, oil wells, coal, chemicals, steel, rubber, etc. Attention was called to the fact that in certain industries where exhaust steam or byproduct fuel was available, the central stations could only hope to get the excess requirements of power or heat.

Remote Control of High-Pressure Steam Lines*

By Peter Payne Dean

This paper is intended to bring out the need of protection other than that of hand-operated valves for high-pressure steam lines in case of failure of pipe or fittings, and deals with the remote operation of various types of valves by electric motor or steam piston in order to stop the escaping steam quickly and safely. It is based on long experience in this field.

The protection of human life should be the first consideration in any plant, and after that continuity of plant operation and protection of property. We never think of asking an operator to trip an oil switch; this is always done from the central switchboard. Therefore, why ask him to mount a boiler or scramble through dark galleries to shut off a steam break, when it can be done from a safe point by merely turning a switch?

The master valves should be those nearest to the boiler, and either the automatic stop checks or gate valves in the boiler leads. Valves at these points protect the complete piping system, and would not be affected by the mechanical movement of a broken line.

Automatic stop-check and boiler-lead gate valves are seldom above 10 in. in diameter, and can be closed in from 15 to 30 sec., so that any or all of the boilers may be cut out at will.

Unless all the boilers are isolated, there may be a reverse flow from the header back through the break, so that a master valve is also necessary in the boiler lead at the header. Closing both the boiler lead valve and this last-mentioned valve completely isolates one boiler. Boiler lead valves are suggested because they protect the whole system of piping from the superheater out, and because, on account of the large sizes of the valves in the header and the immense rush of steam, it would be almost useless to endeavor to sectionalize the header to stop the flow.

The principal argument against emergency closing off of the boiler is that the plant would be completely shut down. In the author's opinion, if a bad break occurs its localization cannot be determined until almost the entire steam supply is stopped. As soon as the break is located, the sectionalizing valves may be brought into play and the boilers quickly brought back on the line.

Even though large header valves can be closed from a distance, the author believes that the quick and safe way is to shut off the sections one at a time until the break is stopped. Incidentally, with any remote closing scheme the boiler safety valves should be piped to a header leading to the atmosphere, as in the event of a boiler shutdown they would all blow together. Some arrangement of an auxiliary header should also be worked out to supply the boiler-feed pumps, as well as a scheme for shutting down the draft fan. Power-operated header valves of large diameter may be depended upon to stop a very bad fitting, blow or gasket leak, so for this reason, and also for convenience of operation, they should be provided with remote control.

Careful attention should be given to the central switchboard from which the valves are controlled. The location should be as near the main exit as possible, because plant operators in case of trouble will move toward that point. With the open air in view a man is more likely to act calmly. Such stations should never be placed in steam-

*Abstract of paper presented at annual meeting of A.S.M.E., Montreal, Canada, May 28-31, 1923.

tight vaults adjacent to the boiler room and without means of safe exit. The operation of switches to set the valves should be as simple as possible, preferably by breaking a protective glass window and pushing a button. In order to allow the operator to see exactly what he is doing, the face of the valve-control switchboard should be provided with a plainly marked miniature representation of the complete scheme of station piping, with push buttons to represent the valves. Red and green indicating lights should be provided to show whether the valves respond, and to indicate the general position of the valves in the complete system.

There are two types of quick-acting valves, the straight triple duty and the piston-operated trip valve, both of which are of the globe type. The former is a combination of non-return, stop and "automatic closing on drop of line pressure." The third duty is operated by an electrically controlled pilot valve admitting steam on top of the closing cylinder, which has a piston slightly larger than the disk.

The straight trip valve closes with the pressure and is remotely operated by a solenoid magnetic latch. This valve is used chiefly as a special emergency turbine stop rather than for line protection. The triple-duty remote-control valve would seem to be the logical type for quick closing, provided it can be made to close against the extreme velocity that would result from an open line blowing to atmosphere.

A high steam discharge is likely to carry slugs of water, and there may be some doubt as to the advisability of instantly closing a valve under this condition. It would seem that a closing time of 10 to 15 sec. would be safer.

Electrical operation of non-return valves was first suggested by the author and has been adopted by many leading engineers. The operation is the same as that required on the triple-duty design, with the exception that the valve stem is driven by a motor provided with reduction gearing. Their action is positive under the most extreme conditions, provided the motor control is of proper design and application. In connection with the design it is necessary to arrange that the motor shall not jam the disk against its seat so hard as to injure it. At the same time it must seat tightly under all conditions.

Tests recently made at the Essex Station showed that valves of this description up to 10 in. in diameter may be safely closed under emergency conditions, and from a careful study of their behavior it seemed safe to recommend them for the protection of lines up to 12 and 14 in. in diameter.

For emergency closing with an unknown direction of steam flow in the line, there seems to be little choice as to the type of gate-valve construction.

The motor on any remote-controlled valve must be designed to operate under the most severe conditions in an atmosphere laden with dust and high-temperature saturated steam. It must start without resistance after long periods of inactivity and not be affected by steam and water from leaks.

The station should be provided with lamp indications showing the full open and closed position of the valve at all times. The control switch should be provided with a lock, an emergency glass window and a hammer.

A valve-control system should be connected to the most reliable source of current in the station, which is either the direct-current exciter or the switch-control battery circuit. The voltage should not exceed 250. Each valve should be provided with a local control station. Hand-wheels should be provided in case of failure of current supply. Every electrically operated valve should be opened and tested at least once a week, under load conditions if possible. An examination of the internal parts should be made at least once a month and all records of such tests and examinations kept on file.

In testing a boiler burning solid fuel, the length of the test is determined by the rate of combustion and the unavoidable error in equalizing the amounts of fuel on the grate at the start and finish. This time is rarely less than 24 hours, and may reach a week.

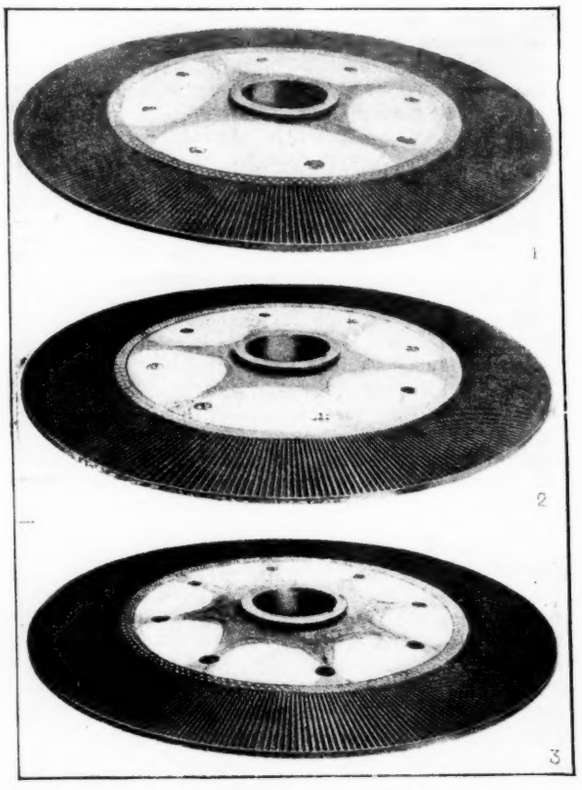
Measuring CO_2 by Gas Friction

A novel CO_2 recorder that neither uses any chemicals nor embodies any delicate electrical or other devices, is described in a recent issue of *Engineering*, London.

The essential parts of this instrument, which is of European origin, are two fans that are kept in rapid rotation by means of a small electric motor. The fans run at the same speed, each in its own chamber and adjacent to a disk. The latter is provided with vanes and is so mounted that it tends to rotate owing to the friction of the air or gas set in motion by the vanes of the driven fan. The tendency to rotate is proportional to the density of the gas in the chamber, and this fact is taken advantage of to determine the percentage of CO_2. One chamber is supplied with flue gas, the other with air. The flue gas is previously cooled and purified so that the gas and the air have the same temperature and humidity. The shafts of the two torque disks are provided with levers so connected by a link that they oppose each other and come to a definite position for any given density of flue gas, that is, for any given percentage of CO_2.

Vibration of Steam-Turbine Disks

The distribution of areas that vibrate and those that tend to remain free from vibration, in a turbine disk, are described in a recent issue of *Engineering* (London). From Fig. 1 it will be observed that the sand that is placed on a vibrating turbine disk has been thrown into the portions that do not vibrate. There are four vibrating areas that are free from sand, and these are situated on two diam-



FIGS. 1, 2 AND 3—VIBRATING AREAS OF TURBINE DISKS ARE FREE FROM SAND

Fig. 1—Vibrates at two nodal diameters. Fig. 2—Disk vibrating on three nodal diameters. Fig. 3—Indicates four nodal diameters.

eters referred to as nodal diameters. Fig. 2 illustrates a turbine disk vibrating on three nodal diameters. The sand figure is symmetrical, with two vibrating areas on each diameter. Fig. 3 shows vibration on four nodal diameters with eight vibrating areas.

Vibration of this kind has received intensive study during

late years, in its relation to the operation of steam turbines. Fig. 4 shows the calculated frequencies of vibration for three designs of turbine disks, disk *C* being considered as fixed centrally at a radius of 5.7 in. and also as being without any fastening. The article does not state, specifically, how the disks *A* and *B* are fastened, but the inference is that the calculations are based on their being pressed on a rigid turbine shaft. It will be noted that the

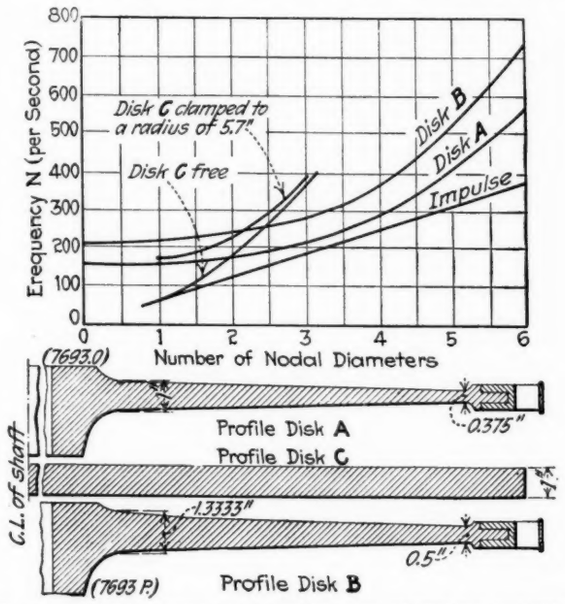


FIG. 4—CALCULATED RELATION OF IMPULSE TENDING TO SET UP VIBRATION AND CORRESPONDING FREQUENCIES

disk *A*, at a frequency of 200 cycles per second, vibrates approximately at three nodal diameters, and that this frequency is very close to that of the impulse that tends to set it up. The impulse, in this region, is only 11 per cent of frequency removed from the actual vibration of the disk.

TABLE I—RELATION OF CRITICAL SPEED TO DISK THICKNESS

Relative thickness	1.0	1.1	1.2	1.3	1.4
Relative critical speed	1.0	1.08	1.16	1.24	1.3

TABLE II—RELATION OF CRITICAL SPEED TO DISK DIAMETER

Relative outside diameter	1.0	1.1	1.2	1.3	1.4
Relative critical speed	1.0	0.85	0.75	0.63	0.55

It would, therefore, be dangerous to build a turbine with this disk, operating at a speed in the neighborhood of 200 cycles per second, or in other words, 12,000 r.p.m.

Disk *B* is considerably farther removed from the impulses causing vibration and is, therefore, safer. The upper curve of disk *C* leaves the impulse line rapidly above 150 cycles, so that this disk would be much safer for operating speeds corresponding to impulse frequencies.

The critical speeds of vibrating disks increase almost directly as the thickness, provided the diameters are kept constant; Table I shows this relation. The critical speeds of disks of constant thickness decrease with the enlarging of the outside diameters as illustrated in Table II.

Guarantees 85 per Cent Boiler Efficiency

With expressions of mingled interest and skepticism David Brownlie, in a recent issue of the *Electrician* (London), tells of a new boiler installation for which the contractors will guarantee an over-all net efficiency of 85 per cent when burning a coal of 10,800 B.t.u. per lb. The horizontal water-tube boilers have each 8,619 sq.ft. of surface and work at 210 lb. pressure, with an evaporation (including the economizer) of 60,000 lb. of water per hour at normal load and 75,000 lb. at overload. Each boiler has 3,190 sq.ft. of superheating surface, and will deliver the steam at 677 deg. F. The cast-iron economizers are of the latest high-pressure horizontal design with a heating surface of 4,620 sq.ft. and are expected to raise the temperature of the feed water at normal rating from 180 deg. to 285 deg. An air heater operated by the flue gases will supply air to the stokers at 220 deg.

In commenting on this remarkable guarantee, Mr. Brownlie calls attention to the fact that the 85 per cent efficiency must be figured on the basis of the total heat in the fuel and not on the lower heating value, as is generally customary in England. The performance of this guarantee is rendered still more difficult by the fact that deduction is to be made for all power used by the auxiliaries, at the rate of 18,900 B.t.u. per kw.-hr.

"In order to get a net efficiency of 85 per cent on these lines," says Mr. Brownlie, "some of the exit temperatures that will be necessary are rather startling, to say the least. Thus the gases must leave the boiler and superheater at 646 deg. F. as usual, at the normal rate of evaporation. The superheater is to raise the steam from 392 deg. F. to 677 deg. F., and the gases then enter the economizer and raise the temperature of the feed water from 180 deg. to 285 deg., as already stated, leaving at 396 deg. They then enter the air heater at this temperature and heat up the volume of air required for the stoker, 1,273,000 cu.ft. per hour, from 60 deg. F. to 220 deg. F., while the excess gases finally pass to the chimney at 236 deg."

Honor Memory of First President

The National Association of Stationary Engineers unveiled the memorial monument that they have erected to the memory of their first national president, Henry D. Cozens, at Fairmont Cemetery, Newark, N. J., on Memorial Day. Mr. Cozens had been an active member of the association for forty years.

MONUMENT ERECTED TO HENRY D. COZENS

News in the Field of Power

Ohio's Engineers' License Laws Defeated

Ohio Engineers' License Law failed for passage during the session of the legislature just ended. An examination of the bill showed that it applied only to engineers engaged on work for which public funds are expended, and the defeat of the bill was due to the opposition of the engineers themselves. A ballot taken by the Engineers' Club of Cincinnati among the societies of Ohio showed a decided opposition to it as follows: American Society of Civil Engineers—in favor, 54; American Society of Mechanical Engineers—opposed, 84; American Institute of Electrical Engineers—opposed, 83; American Institute of Chemical Engineers—opposed, 80. The members of these societies did not, however, receive a copy of the bill for consideration. Engineering societies in Ohio that did receive copies of the bill voted as follows: Akron Engineers' Club and affiliations—in favor, 58; Columbus Engineers' Club and affiliations—in favor, 84; Ohio Engineering Society—in favor, 93; N. W. County Surveyors' Association of Ohio—in favor, 95; American Association of Engineers in Ohio—in favor, 94.

American Order of Steam and Electrical Engineers Meet

The thirty-seventh convention of the American Order of Steam and Electrical Engineers was held at Reading, Pa., during the week beginning June 4. The American Hotel, a short walking distance from the building, in which the meetings of the delegates and the supply men were held, was headquarters.

The several sessions of the delegates were held in the reception room of the Auditorium. There were upward of fifty delegates present when the first meeting was called to order at ten o'clock, Monday morning, to listen to the annual address of the supreme chief, at the close of which the necessary committees were appointed. Many important resolutions were presented and harmoniously acted upon during the week. The organization is in a sound financial condition. One measure passed by the delegates permits the forming of Ladies' Auxiliaries by the various local councils.

The main hall of the Auditorium was conveniently arranged and pleasingly decorated for the use of the American Supply Men's Association for the display of power-plant equipment and engine-room accessories. The exhibit was well attended by the residents of Reading and also attracted visitors from the near-by cities. During the week pupils from the manual training department of the high school and also the engineering classes of the Keystone Institute inspected the display.

The preliminary exercises of the convention and the official opening of the exhibit took place on Monday evening at the Auditorium by the declaration by the supreme chief, George T. Crum, and the unfurling of a large flag of the City of Reading. D. B. Heilman was the master of ceremonies and, after a brief speech outlining the plans of the association, introduced the following speakers, who made addresses of welcome: John K. Stauffer, Mayor of Reading, W. H. Elridge, secretary of the Chamber of Commerce; Jacob H. Reichert, manager of Reading's 175th Anniversary. Responses were made by George T. Crum, J. Maurice Willitts and John W. Armour.

On Wednesday night there was an enjoyable get-together meeting for the men, at which there were entertainment and refreshments. Thursday evening there was a well attended vaudeville entertainment held at the Auditorium. During the week visits were made to the city water works, Reading Iron Co., Narrow Fabric Plant, Vanity Fair Silk Mills and the Metropolitan Edison Company plant.

The election of the supreme officers of the engineers resulted as follows: Charles Berger, chief, Kensington, Pa.; Horace Hewling, assistant chief, Camden, N. J.; Charles Hartmen, recording engineer, Baltimore, Md.; W. S. Wetzler, corresponding engineer, Philadelphia, Pa.; John J. Kelly, treasurer, Philadelphia, Pa.; Oscar Kurtz, senior master mechanic, Germantown, Pa.; Robert Altemose, junior master mechanic, Coplay, Pa.; Raymond Bowman, inside sentinel, Reading, Pa.; Harvey Berger, outside sentinel, Reading, Pa.; Joseph High, chaplain, Philadelphia, Pa.; George T. Crum, trustee, Baltimore, Md.

The officers for the ensuing year elected by the American Supply Men's Association included Andrew Lauterbach, president, The Lunkenheimer Co.; Everett J. Downs, vice-president, Lord's Boiler Compounds; John W. Armour, treasurer, *Power;* William J. Brice, secretary, Ford & Kendig Co.; A. R. Nelson, director of exhibits, Tide Water Sales Corporation.

Ford Secures License for High Dam Project

License for Fifty Years Calls for a Rental of $95,440 per Annum

A license extending to Henry Ford the right to utilize the High Dam on the Mississippi River at St. Paul, for a period of fifty years, has been executed finally by the Federal Power Commission. The license covers the construction of a power house on the existing substructure at the St. Paul end of the dam. The power house will be equipped with four turbo-generating units, each with a capacity of 4,500 kva., or 500 kva. in excess of the minimum figure named in the preliminary permit.

Three-foot flash-boards will be placed on the dam so that water may be ponded during off hours and so that the head may be raised in ordinary high water. Mr. Ford will construct a steam auxiliary on the bank adjacent to the hydro power house. The capacity of this auxiliary has not been determined finally, but presumably will be 15,000 hp., since there is about that much difference between his firm power and his secondary power at the dam. This steam plant will be designed to burn refuse from the plant and to furnish steam for heating the factory.

Mr. Ford's representatives presented to the Federal Power Commission a signed contract with the Northern States Power Co. whereby the latter agrees to use all the available power, in excess of the needs of the manufacturing plant at a fixed price of 2½ mills per kilowatt-hour.

It is understood that Mr. Ford is planning to manufacture storage batteries for his cars at this plant. The estimated output of the plant will be 6,000 batteries per day.

The matter of establishing a barge service between St. Louis and St. Paul has been taken up with the War Department by Mr. Ford. It is his plan to bring in the lead and other raw materials entering into battery construction by barge and load these river craft with the manufactured product for return cargo. The Federal Government has been operating a barge line from St. Louis to New Orleans for several years. If arrangements can be made for a line of barges on the upper river, Mr. Ford will have the advantage of the lower transportation rate which is in effect on river movement.

The license was accepted with the reservation that an argument later may be presented by Mr. Ford's representatives for a reduction in the capital sum being paid for the use of the government structure and for a reduction in the rate of interest. In the report of the Chief of Engineers, it is suggested that $70,000 per annum would be fair reimbursement to the government. The license calls for $95,440 per annum.

Purchases of Commodities to be Standardized

A conference was held, on June 11, at the Department of Commerce, of various technical and other associations to form an Advisory Committee to cooperate with the Department of Commerce and the States Purchasing Agents Association in the work of formulating purchase standards, specifications and tests.

The Federal Specification Board has had under review federal specifications, and in formulation of such specifications has made necessary scientific investigations and has called into consultation representatives of the manufacturing industries concerned, in order that the government purchases should be properly adapted to the manufacturing processes and normal stocks and materials of the country. A considerable amount of economy has been effected and the federal government supplies, by these methods and others, better adapted to commercial practice.

The State Purchasing Agencies have from time to time sought the assistance of the Department of Commerce in the formulation of standards, specifications and methods of test for their purchases also. It is to organize these agencies better, to establish co-operation with technical and scientific bodies of the country and to take advantage of the experience of large buyers and manufacturing representatives that this Advisory Board is now being created. It is proposed to formulate a handbook of specifications for the use of public purchasing agents covering the entire field of standards, specifications, simplifications and tests. This Advisory Board is the outcome of a meeting of the State Purchasing Agents on May 26, which Secretary of Commerce, Mr. Hoover, addressed.

Joint Fuel Committee Assists Public Service Corporations

That 225 concerns representing industries essential to public welfare have received service in some form from the Joint Fuel Committee was brought out by John W. Lieb, chairman, who spoke at the N.E.L.A. convention, June 8, at New York. Another service rendered by this committee, which alone might be considered as offsetting the expenses involved, was that of establishing a direct personal contact with the governmental departments in Washington which were connected with fuel activities.

Service to public utilities in some cases consisted of merely furnishing advice or information, while at other times it was necessary to go to great lengths in order to obtain delivery of requisite fuel. It was urged that coal be stored to the limit, in anticipation of the probable railroad congestion next fall. Annual contracts should include sufficient fuel to cover all requirements without relying on the chance of obtaining lower prices for a portion of the fuel at some time during the year. Clauses in such contracts should specify actual delivery of a definite quality of coal.

Mr. Lieb spoke at some length of the results attending personal contact with government officials. Much information was supplied directly; policies of great importance and money value were built up with the assistance of the committee; coal storage was minutely discussed. Concerning priority, the committee made recommendations including considerations of the relative location of mines and plants which had not before been recognized.

New Hydro-Electric Laws Contemplated in Alabama

When the Alabama State Legislature reconvenes, July 10, Walter Brower, state senator from Jefferson County, will introduce a bill prohibiting the sale, outside of the state, of hydro-electric power produced within it. Senator Brower's bill provides that a committee be named jointly by the state senate and house to make a survey of all water power within the state, both developed and undeveloped, for the purpose of determining the present and future amount of power required by the industries of Alabama. Senator Brower said: "Should my bill become a law, it will have a tendency to keep sufficient electrical power within the state and to keep prices down where they should be. Alabama's water power is one of the state's greatest assets, and we really do not know how much we have." At the present time power companies within Alabama are selling hydro-electric power produced in the state over transmission lines to several places in Georgia and North and South Carolina.

Power-Plant Equipment Needed in China

From government reports machinery for generating electricity to light ten towns in the Antung, China, consular district is desired by a Chinese firm which is reported to have orders to install these plants. The capacities needed range from 11 to 110 kw., or sufficient to supply 700 to 5,000 16-candlepower lights. The firm desires to act as agent for an American manufacturer who wishes representation in the district tributary to Antung. Further particulars may be obtained from the Electrical Equipment Division, Washington, D. C., or through the Bureau's district or co-operative offices by referring to file No. 85923.

A tentative ruling of the Industrial Board, Department of Labor and Industry of the Commonwealth of Pennsylvania, in regard to miniature boilers, provides an amendment to Rule 003 in supplement to the Boiler Code, by adding a new paragraph: "All boilers having a grate area of not more than 1 sq.ft., or a heating surface of not more than 15 sq.ft. and carrying a steam pressure of not more than 100 pounds per sq.in. shall have a water feed system that will permit of the boilers being fed while under pressure."

New Publications

Central Electric Stations in Canada, Part II Directory. By the Dominion Water Power Branch of the Department of the Interior, Canada. Water Resources Paper No. 33. Published by F. A. Acland, Ottawa, Canada. Second edition. Paper; 5½x9¾ in.; 483 pages. Available for distribution upon application to J. B. Challies, Director of Water Power, Dominion Water Power Branch, Ottawa, Canada.

This directory, concisely and interestingly gotten up, with a foreword and preliminary chapter on water power in Canada, gives the name, location, kind of plant, names and addresses of officials, capital invested, history, installation, transmission system, distribution system, service disposition, output, use of power and rates for the 826 central electric stations listed in it. Maps, tables and graphs adequately illustrate this statement of Canadian power resources to Nov. 1, 1922.

Marine Engines. By A. Ritchie Leask. Published by Simpkins, Marshall & Co., Ltd., London, and D. Van Nostrand Co., New York. Cloth; 6x9 in.; 424 pages; 224 illustrations. Price, $7.50.

As a means of acquainting young marine engineers with the several types of engines and auxiliaries, this volume possesses considerable merit. The author has indulged in no deep thermodynamic theories, but has consistently held to his chosen course of discussing the subject in plain understandable language. The volume, however, is open to the criticism that it is somewhat illogically arranged. It would have been more reasonable to have discussed valves and valve setting before taking up the comparative efficiencies of turbines and reciprocating engines. The old-time marine engineer will no doubt agree with the author's stand in favoring the reciprocating engine over the geared turbine. It is rather hard to explain why all authors of steam-engineering volumes should feel that a portion of their work should be devoted to explanations of engineering and thermodynamic terms that are already fully discussed in elementary volumes. The space thus wasted might in the book under discussion have been devoted to operating problems or to some of the problems of present-day boilers.

The American Engineering Standards Committee has just issued its 1923 year book of 47 pages. It covers the activities and developments of the committee for the year 1922 and contains a list of standardization projects, the sponsors for them, the status of the project and a list of co-operating bodies.

Circular of the Bureau of Standards, No. 138—A Decimal Classification of Radio Subjects—an extension of the Dewey System. Price, 10 cents. Government Printing Office, Washington, D. C.

Personal Mention

George A. Orrok, of the Edison Electric Co., sailed for Europe on Thursday with the intention of investigating various power plants over there.

F. E. Erlander has been appointed manager of the New York branch of the Garlock Packing Co. to succeed Claude Allen, who has taken charge of the San Francisco branch.

Julian C. Smith, vice-president and general manager of the Shawinigan Water & Power Co., of Montreal, has been elected president of the Quebec Railway, Light, Heat & Power Co.

E. W. Robinson, formerly assistant chief engineer of the E. W. Clarke & Company Management Corp., at Columbus, Ohio, has joined the Alabama Power Co., Birmingham, in the capacity of assistant superintendent of distribution.

Eric A. Lof, well known to engineers through papers and lectures, who has been connected with the power and mining engineering department of the General Electric Co. as industrial engineer and specialist, has resigned to take a position with the American Cyanamid Company.

Business Notes

McClave-Brooks Co., Scranton, Pa., announce the opening of a branch office in Cleveland, Ohio, under the management of Mr. J. W. Whitmore, formerly of the Scranton office, also that the Dennis Engineering Co., 243 High St., Columbus, Ohio, has been appointed to represent the firm in western and southwestern Ohio.

Sanford Riley Stoker Co., of Worcester, Mass., announces that Samuel B. Flagg has become associated with the company and will be a special representative at the New York City office. Mr. Flagg was formerly associated with the Bureau of Mines and later with Electric Bond & Share Co., as fuel expert.

Trade Catalogs

Car-Puller, Electric Capstan—Gifford-Wood Co., Hudson, N. Y. Bulletin No. 74, describes this useful plant accessory.

Transmission, Variable Speed—Reeves Pulley Co., Columbus, Indiana, Catalog T-44, contains descriptions, tables, diagrams and illustrations of installations of these transmissions.

Stoker, Level Fuel Bed Underfeed—Detroit Stoker Co., Detroit, Mich. Bulletin, "Built on Advanced Engineering Principles," describes and, with many drawings and photos, illustrates the making and action of this stoker.

Hoists—Sullivan Machinery Co., People's Gas Building, Chicago, Ill. Pulletin 76-C describes "Turbinair," single-drum type HA, and Bulletin 76-D describes "Turbinair," double-drum type HDA. These bulletins have photos and drawings which illustrate the use of these small hoists.

Pumps, Bethlehem-Weir Land Service—Bethlehem Shipbuilding Corp., Ltd., Bethlehem, Pa. Catalog WC gives good descriptions of reciprocating, reciprocating boiler-feed, turbo-feed, service, hydraulic pressure, fuel oil service-horizontal, forced-lubrication, oil transfer, heavy-duty oil, and high-pressure pipe-line pumps, with specifications, sizes and capacities. There are also included useful tables and charts covering loss of head due to flow, density, viscosities, and other data in regard to oils.

Conduits—The Ric-Wil Co., Cleveland, Ohio. Collection of bulletins and pamphlets comprising: Bulletin No. 10 describing type DA conduit; Bulletin 20, describing type DF conduit; Bulletin 30, describing SPC conduit; Bulletin 40, describing F type conduit; pamphlet No. 2357, covering heating rates; Bulletin No. 3, gives the Ric-Wil methods of underground pipe covering; Bulletin No. 5-A, "Heat and Power Plants that are Ornamental as Well as Useful."

Coming Conventions

American Institute of Chemical Engineers; Dr. J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y. Convention at Wilmington, Del., June 20-23.

American Institute of Electrical Engineers; F. L. Hutchinson, 29 West 39th St., New York City. Summer Convention at Swampscott, Mass., June 25-29.

American Institute of Mining and Metallurgical Engineers; F. F. Sharpless, 29 West 39th St., New York City. Annual meeting at Ontario, Quebec, Canada, Aug. 20-31.

American Society for Testing Materials; C. L. Warwick, 1315 Spruce St., Philadelphia, Penn. Annual meeting at Atlantic City, N. J., June 25-30.

American Society of Civil Engineers; J. H. Dunlap, 33 West 39th St., New York City. Annual Convention at Chicago, July 11-13.

Association of Iron & Steel Electrical Engineers; J. F. Kelly, 1007 Empire Bldg., Pittsburgh, Pa. Iron and Steel Exposition at Buffalo, N. Y., Sept. 24-28.

Canadian Association of Stationary Engineers; Gordon C. Keith, 51, Wellington St. West, Toronto, Canada. 34th Annual Convention at Toronto, Canada, June 25-28.

International Union of Steam and Operating Engineers; Dave Evans, 6334, Yale Ave., Chicago, Ill. Annual convention at Detroit, Sept. 10-15.

National Association of Practical Refrigerating Engineers; Ed. H. Fox, 914-25 East Jackson Blvd., Chicago. Fourteenth Annual Convention at Memphis, Dec. 12-16.

National Association of Stationary Engineers; Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Buffalo, N. Y., Sept. 10-15. Annual conventions and exhibitions of the State Associations scheduled as follows: **Michigan** at Flint, July 18-20. E. C. Smith, 308 Vine St., Kalamazoo, Mich. **New England States Association,** at Manchester, N. H., Manchester hotel, July 12-14; Freeman L. Tyler, 32 Briggs St., Taunton, Mass. **Ohio,** at Dayton, June 21-23; J. H. Weaver, 22 N. Gift St., Columbus, Ohio. **Pennsylvania,** at Buffalo, Sept. 9-10; J. N. Calvert, Crafton Sta., Pittsburgh, Pa. **New York,** at Buffalo, Sept. 9-10; W. T. Meinzer, Third St., near Warburton, Bayside, L. I., N. Y. **Minnesota,** at Duluth, Aug. 8-10; C. A. Nelson, 800 22d Ave. N. E., Minneapolis. **Connecticut,** at Waterbury, June 29-30; L. Van Der Eyk, 251 Wood St., Waterbury.

National District Heating Association, D. L. Gaskill, Greenville, Ohio. Annual convention at Cedar Point, Ohio, June 20-23.

New England Association of Commercial Engineers; James F. Morgan, 53 Devonshire St., Boston, Mass. Power Show at Mechanics Bldg., Boston, Mass., Oct. 29-Nov. 3.

The New England Water Works Association; Frank J. Gifford, 715 Tremont Temple, Boston, Mass. Annual Convention at Burlington, Vermont, Sept. 18-21.

National Exposition of Power and Mechanical Engineering; Charles F. Roth, Room 1102, Grand Central Palace, New York City. Power Show, Dec. 3-8.

Ohio Electric Light Association, D. L. Gaskill, Greenville, Ohio. Annual convention at Cedar Point, Ohio, July 10-13.

Smoke Prevention Association; Frank Chambers, 111 N. Dearborn St., Chicago, Ill. Convention at Minneapolis, Minn., June 19-22.

Society for the Promotion of Engineering Education; F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa. Annual meeting at Cornell University, Ithaca, N. Y., June 20-23.

Universal Craftsman Council of Engineers; John F. Amos, P. O. Box 299, Rochester, N. Y. Convention at Rochester, N. Y., Aug. 7-11.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	June 4, 1923	June 11, 1923
Pool 1,	New York	$3.50@4.00	$3.50@4.00
Smokeless,	Columbus	4.00@4.50	4.00@4.50
Clearfield,	Boston	2.00@2.75	2.25@3.00
Somerset,	Boston	2.50@3.25	2.50@3.25
Kanawha,	Columbus	1.90@2.20	1.90@2.20
Hocking,	Columbus	1.75@2.00	1.75@2.00
Pittsburgh No. 8	Cleveland	2.15@2.25	2.00@2.10
Franklin, Ill.	Chicago	3.00@3.25	3.00@3.25
Central, Ill.	Chicago	2.00@2.25	2.00@2.25
Ind. 4th Vein,	Chicago	2.50@2.75	2.50@2.75
West Ky.,	Louisville	1.75@1.85	1.65@1.85
S. E. Ky.,	Louisville	2.00@2.50	2.00@2.50
Big Seam,	Birmingham	1.85@2.25	1.85@2.25

FUEL OIL

New York—June 14, Port Arthur light oil, 22@25 deg. Baumé, 5⅝c. per gal.; 30@35 deg., 5¾c. per gal., f.o.b. Bayonne, N. J.

Chicago—June 9 24@26 deg. Baumé, $1.97 per bbl.; 32@36 deg., $2.27 per bbl. tank cars.

St. Louis—June 5, tank-car lots, f.o.b. St. Louis; 30@32 deg. $1.90 per bbl., 26@28 deg., 1.80 per bbl.; 28@30 deg., $1.85 per bbl.; 32@36 deg., gas oil, 4¾c. per gal.; 36@40 deg., distillate 5½c. per gal.

Pittsburgh—June 5, f.o.b. local refinery, 30@34 deg., fuel oil, 4¼c. per gal.; 36@40 deg., fuel oil, 5¼c. per gal.; 34 deg., neutral, 8½c. per gal.

Dallas—June 9, f.o.b. local refinery, 26@30 deg,. $1.57 per bbl.

New Plant Construction

PROPOSED WORK

Ark., Imboden—C. G. Buchanan, Morrilton and G. G. Dent will soon award the contract for city distribution system and pumping plant, including 1 centrifugal pump and engine. Estimated cost $25,000.

Ark., Little Rock—The Arkansas Central Power Co., C. J. Griffith, Genl. Mgr., plans addition to light and power plant. Estimated cost $75,000.

Ark., Paragould—The city plans extensive improvements in water works system, including new pumps, concrete reservoir, pipe work, etc.

Calif., Delano—The city will receive bids about July 1, for furnishing deep well turbine pump about 750 to 900 g.p.m. capacity. J. S. Bates, Howell Bldg., Fresno, Engr.

Calif., Lodi—The Gloria Ice Cream Co., Oak and Aurora Sts., Stockton, plans to build a 55 x 220 ft. warehouse and refrigerating plant on Lockeford St., here. Cost will exceed $50,000.

Calif., Los Angeles—The city defeated $35,000,000 bond issue for developing 250,000 hp. at Boulder Canyon. Noted May 29.

Calif., Los Angeles — The Los Angeles Gas & Electric Corp., W. Baurhyte, V. Pres. and Genl. Mgr., 645 South Hill St., plans to expend $10,700,000 as follows: additions and betterment to existing gas works, $3,000,000; new gas distributing system, $3,000,000; new generator plants, $1,700,000; extensions to present electrical distributing system, $1,100,000; miscellaneous improvements $700,000 and new downtown office building, $1,200,000.

Calif., Sacramento—The State Reclamation Bd., Forum Bldg., will receive bids in two months for the construction of a drainage pumping plant, consisting of centrifugal type pumps with combined capacity of 120,000 g.p.m. with electric motors; priming equipment; pump house, etc., for reclamation Dist. No. 1660. Cost will exceed $90,000.

Calif., San Francisco — The City Park Commission will soon receive bids for furnishing pump and motor for Sloat Blvd. swimming tank, pump about 7,000 g.p.m., 25 ft. maximum head, centrifugal type.

D. C., Wash—J. A. Wetmore, Acting Supervising Archt., Treasury Dept., will receive bids until June 25, for furnishing and installing 2 portable smokeless fire-box steel heating boilers, etc., at the United States Custom and Court House, Toledo, Ohio.

Fla., Tampa—The Chemical Constr. Co., Trust Bldg., Charlotte, N. C., C. C. Nott, Pres. of Bd., plans to build a phosphate plant on Hillsborough Pier, near here. Estimated cost $1,500,000.

Ill., Chicago—Balaban & Ketz, 181 North State St., are having plans prepared for the construction of a theatre, seating capacity 5,000, including steam heating system, on Broadway and Lawrence St. Estimated cost $5,000,000. Rapp & Rapp, 190 North State St., Archts.

Ill., Chicago—Edelson & Paulson, 11 South La Salle St., are having plans prepared for the construction of an 8 story, 80 x 125 ft. apartment hotel and store building, including steam heating system, at 840 Sheridan Rd. Estimated cost $900,000. Loewenberg & Loewenberg, 111 West Monroe St., Archts.

Ill., Chicago—R. D. Huszagh, Archt., 105 North Clark St. and F. U. Malwin, owner, 54 West Randolph St., are receiving bids for the construction of a 3 story, 100 x 150 ft. hotel, including steam heating system, on Broadway and Buena Park St. Estimated cost $250,000.

Ill., Joliet—The Eagle Paper Co. is having plans and specifications prepared for the installation of additional boiler and generating equipment. Cahill & Douglas, 217 West Water St., Milwaukee, Engrs.

Ill., Rockford — The Rockford Power Mchy. Co., 621 7th St., R. A. Brown, Purch. Agt., is in the market for electric motors, all sizes (used).

Ill., Taylorville—The city council, H. D. Mills, Clk., City Hall, will receive bids until July 16, for the construction of an electric light and power plant.

Ind., Bloomington—The University of Indiana is having plans prepared for the construction of a memorial building and dormitory, including steam heating system. Estimated cost $1,250,000. Loee & Bollenbacher, 108 South La Salle St., Chicago, Archts.

Ind., Mount Vernon—The Southern Indiana Gas & Electric Co., Evansville, plans extensions to transmission lines, additions to power plant, electrical equipment, etc., here. Cost will exceed $25,000.

Kan., Holton—Black & Veatch, 701 Mutual Bldg., Kansas City, Mo., will receive bids until June 22 for one 300 hp. oil engine for the city, here.

Kan., Mulvane—The city, N. Sharp, Clk., is in the market for a 50 hp. motor. F. Sharp, City Engr.

Ky., Louisville — Joseph & Joseph, Archts., Francis Bldg., will receive bids until June 30 for the construction of a temple, to contain 400 rooms, including auditorium on Broadway, for the Kosairs Assn. Estimated cost $1,750,000. Equipment detail not reported. Noted May 22.

Ky., Whitesburg—The Knott Coal Corp., Roanoke, Va., plans to build a tipple and install equipment, including fans, pumps, etc., for new mines near here.

La., New Orleans—The Grunewald Hotel, Baronne St., J. Vaccaro, Pres., is having plans prepared for the construction of a 20 story hotel. Cost between $3,000,000 and $4,000,000. Favrot & Livaudais, Hibernia Bank Bldg., New Orleans, and Toledano, Wogan & Bernard, Title & Guarantee Bldg., New Orleans, Archts. Equipment detail not reported.

La., New Orleans—The U. S. Engineers Office, War Dept., will receive bids until July 5, for the construction and delivery of two 20 in. dredging pumps.

Mass., Boston—The Boston Elevated Ry. Co., 108 Massachusetts Ave., E. Dana, Genl. Mgr., is in the market for machinery for addition to the turbine room at its power plant at South Boston.

Mass., Boston—Goggin & Ripley, 350 Madison Ave., New York, are having plans prepared for the construction of a 7 story, 50 x 90 ft. apartment house at 301 Berkely St., here. Estimated cost $750,000. Parker, Thomas & Rice, 177 State St., Boston, Archts. Equpiment detail not reported.

Mass., Boston—The Public Wks. Dept., will receive bids until June 21 for the construction of a 2 story, 53 x 220 ft. garage and boiler room with 31 x 65 ft. ell, on Albany St. Estimated cost $150,000. Mulhall & Holmes, 248 Boylston St., Archts. Noted June 12.

Mich., Lansing—E. A. Bowd, Archt., 127 West Allegan St., will soon award the contract for the construction of a 7 story, 100 x 165 ft. temple on South Capitol Ave. for the Masonic Temple Assn., Amer. State Savings Bank Bldg. Estimated cost $750,000. Equipment detail not reported.

Minn., Clarkfield—The village will receive bids until June 22 for the construction of waterworks extensions and improvements, including pipe, hydrants, castings, pump house and pumping equipment. Estimated cost $15,000. J. A. Rowat, Willmar, Engr.

Minn., Emmons—The city, A. H. Rasmusson, Recorder, will receive bids until June 29 for the construction of a waterworks system, including mains, well, motor, pump house, tank and tower. Estimated cost $15,000. Toltx, King & Day, 1410 Pioneer Bldg., St. Paul, Engrs.

Minn., Litchfield—The city, F. O. Holm, Clk., is having plans prepared for enlarging electric light and power plant. Estimated cost $75,000. L. P. Wolff, 1000 Guardian Life Bldg., St. Paul, and E. D. Jackson, 403 Endicott Bldg., St. Paul, Engrs.

Miss., Louisville—The town voted $30,000 bonds for equipment for electric light plant. Noted June 12.

Miss., Purvis—The Kramer Engineering Co., Magnolia, is preparing plans for the construction of a municipal electric system and improvements here.

Mo., Cameron—The city will hold an election June 22 to vote on $175,000 bonds; $85,000 for electric light plant and transmission lines, etc.; $51,000 for waterworks; $39,000 for sewers. E. E. Harper, 3031 Park Ave., Kansas City, Engr.

Mo., St. Louis—The B. Nugent & Bros. Dry Goods Co., Washington St. and Broadway, has had preliminary plans prepared for the construction of a 10 story, 160 x 160 ft. department store. Estimated cost $3,000,000. Private plans.

N. J., Pennington—The city council will receive bids until June 25 for the construction of a water system, including mains, hydrants and electrically operated pumping station. Remington & Vosbury, 601 Market St., Camden, Engrs.

N. J., Trenton—The Pennsylvania R.R. Co., Broad St. Sta., Phila., Pa., plans to build a passenger station, here. Cost between $900,000 and $1,000,000. A. C. Shand, Ch. Engr.

N. Y., Brooklyn—The Bd. Educ., 500 Park Ave., New York, will soon receive bids for the construction of a 5 story, 65 x 215 ft. high school, including steam heating system, on Union and President Sts., here. Estimated cost $2,000,000. W. H. Gompert, Flatbush Ave. Extension and Concord St., Brooklyn, Archt.

N. Y., Brooklyn—The State Laundry Co., 764 Myrtle Ave., is in the market for a generator, 125 kw., 125 to 250 volt, d.c., connected to engine.

N. Y., Brooklyn—The United States Veterans Bureau, Arlington Bldg., Wash., D. C., is receiving bids for auxiliary system for heating stores 1 and 2 at South Brooklyn, N. Y., No. 4856.

N. Y., Buffalo—The Liberty Bank, 424 Main St., will soon receive bids for the construction of a 15 story bank and office building. A. C. Bossom, 680 5th Ave., New York, Engr. and Archt. Equipment detail not reported.

N. Y., Mineville—The Witherbee-Sherman Co. plans to repair its power house, which was recently damaged by fire at Cookshaft. Cost between $75,000 and $100,000.

N. Y., New York—The 5th Ave. and 46th St. Corp., B. P. Walker, c/o Schwartz & Gross, Engrs. and Archts., 347 5th Ave., will build by separate contracts under supervision of architect, a 16 story, 100 x 100 ft. office building at 2 West 46th St. Estimated cost $1,000,000. Equipment detail not reported.

N. Y., New York—The Kaufman Dress Co., c/o C. H. Meyers, Engr. and Archt., 31 Union Sq., will soon receive bids for the construction of a 17 story, 90 x 100 ft. office building on West 35th St. Estimated cost $850,000. Equipment detail not reported.

N. Y., New York—W. N. Smith, Engr. and Archt., 101 Park Ave., is preparing plans for the construction of a 10 story, 50 x 100 ft. apartment on 60th St. and Park Ave. Owner's name withheld. Equipment detail not reported.

N. C., Greensboro—The Agricultural and Technical College, J. B. Dudley, Pres., will soon award the contract for the construction of a power house and laundry building. H. A. Underwood, Jt. Bl. Com., Raleigh, Engr.

N. C., Lexington—The Ponecmah Mills Co. plans to build a power house. Estimated cost $25,000.

N. C., Sanford—The Virginia & Carolina Mining Co., Winston-Salem, plans to build a power house and pumping unit to be connected with mining works, here. Estimated cost $100,000.

N. C., Statesville — The Sheril-Green Furniture Co. plans to build a factory and power house. Estimated cost $75,000. Engineer or architect not selected.

N. C., Waynesville—The Pigeon River Power Co. plans to build a hydro-electric generating plant on the Pigeon River. Estimated cost $250,000. Engineer or architect not selected.

N. D., Fargo—The State Bd. of Administration, Gardner Hotel, E. G. Wanner, Secy., will receive bids June 27 for power equipment, including stokers, coal and ash conveying machinery for State Hospital for Insane at Jamestown.

Ohio, Cincinnati—The Clerk of the Bd. Educ., 511 West Court St., will receive bids until June 25 for furnishing materials and completing heating and ventilating systems in the Hughes High School, Clifton and McMillen Sts., also in Hartwell Public School, Springfield Pike and Hartwell Ave. Estimated cost $25,000 for each. W. E. Bodenstein, 405 2nd Natl. Bank Bldg., Engr.

Ohio, East Palestine—The city plans additional unit for the municipal plant. H. O. Swoboda, Inc., Empire Bldg., Pittsburgh, Pa., Consult. Engrs.

Okla., Muskogee—The city will soon receive new bids for a 7,000,000 gal. pump and equipment. Former bids rejected. J. R. March, Muskogee, Engr.

Okla., Okmulgee — The city is having plans, surveys, estimates and report prepared for various water supply projects, including storage reservoir and dam on Deep Fork Creek, creating a lake, 7 mi. long, covering 25,000 acres; a supply from the Grand River, 45 mi. away and also from the Illinois River. Estimated cost $2,000,000. T. J. Embree, City Engr. Burns & McDonnell, 402 Interstate Bldg., Kansas City, Mo., Consult. Engrs.

Pa., Bedford Springs—Rutan, Russell & Wood, Archts., Century Bldg., Pittsburgh, will soon award the contract for the construction of a 1 story, 60 x 125 ft., 2 story, 65 x 125 ft., also 4 and 5 story, 42 x 336 ft. and 42 x 66 ft. additions to hotel for the Bedford Springs Hotel Co., here. Estimated cost $500,000. Equipment detail not reported.

Pa., Johnstown—The Bd. of Dirs. of Conemaugh Valley Memorial Hispital, F. Krebs, Pres., is receiving bids for the construction of a 4 story 50 x 130 ft. wing of hospital to contain children's and maternity wards, men's surgical department and 50 rooms, on Franklin St. Estimated cost $500,000. W. R. Myton, 1204 1st Natl. Bank Bldg., Johnstown, Archts. H. C. Wright, New York, Associate Archt. Separate contracts will be awarded for foundation, general contract, heating, plumbing and lighting.

S. C., Greenville—The Southern Worsted Corp. is having plans prepared for the construction of a 1 story, 40 x 80 ft. power house. Estimated cost $40,000. Lockwood, Greene & Co., Piedmont Bldg., Charlotte, N. C., Archts.

Tenn., Cookeville—The Maxwell Hill Co. is in the market for ice and cold storage machinery and equipment.

Tenn., Jackson—The Illinois Central R.R., Hibernia Bldg., New Orleans, La., plans improvements and extensions to its yards, terminals, repair shops, compression plant, etc., here. Estimated cost $250,000. W. T. Atwill, Genl. Supt.

Tex., Dallas—J. O. Taft, Archt., 1714 Corsicana St., will soon receive bids for the construction of a 9 story, 90 x 103 ft. hotel on Harwood and Jackson Sts., for E. D. Gonzales, 3029 Bryan St. Estimated cost $311,000. Equipment detail not reported.

Tex., Fort Worth—The City Com. will receive bids until July 3, for a pump, 12,000,000 g.p.d. capacity against 270 ft. head with electric motor or Diesel engine foundations, etc., at Holly Sta. on Fournier St. Estimated cost $80,000. D. L. Lewis, City Engr. J. B. Hawley, Cotton Exch. Bldg., Fort Worth, Consult. Engr. Noted June 5.

Tex., Lufkin—The City Com., T. L. Dunn, Secy., is having plans prepared and will receive bids in July for the construction of a pump house and piping. Estimated cost $15,000. H. N. Roberts, 4227 Irving Pl., Dallas, Engr.

Va., Richmond—The Hackley Morrison Co., Inc., 1708 Lewis St., is in the market for one 12 x 14 belt driven air compressor (used).

Wash., Seattle—The Community Hotel Corp. received low bid for the construction of the new Olympic Hotel, from Grant Smith & Co., Henry Bldg., $3,254,000.

W. Va., Morgantown—S. F. Heckert, Archt., 620 Bessemer Bldg., Pittsburgh, Pa., will receive bids until June 22, for the construction of an 8 story, 49 x 187 ft. hotel, including steam heating system, for the Morgantown Hotel Co. Estimated cost $300,000. Noted Jan. 30.

Wis., Fort Atkinson—The city, W. D. Leonard, Clk., is having plans prepared for the construction of a pumping station, equipment and reservoir, 60 ft. diameter, 15 ft. high. Estimated cost $25,000. W. G. Kirchoffer, Dean Bldg., Madison, Engr. J. R. and E. J. Law, First Central Bldg., Madison, Archts.

Wis., Genoa Junction—The village, W. J. Bill, Clk., is having plans prepared for the construction of a pumping station, storage reservoir, deep well and pump. Estimated cost $15,000. W. A. Pierce, 227 Clifford St., Madison, Engr.

Wis., Green Bay—Christ Episcopal Congregation, c/o G. McMurray, Bellin Bldg., is having plans prepared for the construction of a steam heating plant, including boilers, for parish hall and community building. Estimated cost $25,000. Oppenhorner & Obel, Green Bay, Engrs.

Wis., Madison—The Heilprin Fruit Co., J. Heilprin, Pres., West Mifflin and Bedford Sts., is in the market for large ice machine, belting, shafting and refrigeration machinery for cold storage warehouse.

Wis., Madison—The Madison Auditorium Co., 119 East Washington Ave., C. F. Ellis, Mgr., is having plans prepared for the construction of a 1 story, 50 x 90 ft. central heating plant and equipment. Estimated cost $100,000. Balch & Lippert, Gay Bldg., Madison, Engrs. Owner will purchase boilers, ash handling equipment, etc.

Wis., Manitowoc—The Manitowoc Portland Cement Co., c/o L. E. Geer, 16th and River Sts., is having plans prepared for the construction of a 1 story, 75 x 500 ft. cement mill, including kiln, capacity 3,000 bbl. per day. Estimated cost $1,000,000. Private plans. The owner is in the market for kiln equipment, power machinery, etc.

Wis., Merrill—The Ideal Cooperative Creamery Co. is in the market for dairy and refrigeration machinery, belting and shafting for proposed cheese factory.

Wis., Milwaukee—The Wisconsin Consistory, W. Perry, Van Buren and Oneida Sts., Secy., plans to build a Masonic Temple. Estimated cost $2,000,000. Engineer or architect not selected.

Wis., Waupun—W. F. Bossman, Archt., 419 West 3d St., Beaver Dam, is receiving bids for the construction of a 4 story, 75 x 150 ft. hotel on Lake Emily, for the Schaumburg Country Club, F. E. Gunther, Pres., 1801 West 35th St., Chicago, Ill. Estimated cost $150,000. Architect will purchase private electric generating machinery to furnish electricity.

B. C., Ruskin—The British Columbia Electric Ry. Co., 425 Carroll St., Vancouver, J. I. Newell, Electrical Supt., has had plans prepared for the construction of a 10,000 kw., a.c. 3 phase, 60 cycle light and power plant with one 11,600 hp. water wheel, at Stave Lake, near here. This plant will take water under head of 140 ft. from Alouette Lake down to level of Stave Lake. Additional high voltage line will be installed to connect this plant with Stave Falls. Estimated cost $750,000. Also having preliminary surveys made for the construction of a dam and power plant, 80,000 to 100,000 kw. on Stave River, 2 mi. north of here. Cost between $6,000,000 and $8,000,000. R. S. Kelsch, 702 Power Bldg., Montreal, Que., Consult Engr.

Ont., Eugenia—The Hydro-Electric Power Comn., 190 University Ave., Toronto, is having plans prepared for the installation of a second pipe line and another unit, including wood stave and steel pipe; horizontal turbine, Francis type and generator, about 4,000 hp.; electrical equipment, etc., head 550 ft., here. Estimated cost $150,000. F. A. Gaby, Ch. Engr.

Ont., Ford—The Ford Motor Co. of Canada is having plans prepared for the construction of a 2 story, 112 x 148 ft. power house, one 10,000 kw. turbine unit with provision for second, also 27 x 31 ft. screen house on Sandwich St. A. Kahn, 1000 Marquette Bldg., Detroit, Mich., Archt. The owner is in the market for boilers, coal conveyors, pulverizers, elevators and ash handling equipment.

Ont., South Porcupine—The Davidson Gold Mines, Ltd., King Edward Hotel Bldg., Toronto, J. C. Platt, Secy., plans extensive alterations and additions to its gold mining mill with equipment, including pumps, stamps, crushers, drills and air equipment, electrically driven. Bids will be received for sinking shaft, 1,000 ft. deep. Estimated cost $900,000.

Ont., Thornbury—The town is having plans prepared for a waterworks system, including pump house, pumps, c. i. water mains, hydrants, reservoir or tank, etc. Estimated cost $30,000. James, Proctor & Redfern, 36 Toronto St., Toronto, Engrs.

Ont., Toronto—The Toronto Electric Comn., 225 Yonge St., will soon receive bids for the construction of an addition to hydro-electric substation, on Carlan Ave. and Gerrard St. Estimated cost $300,000. Private plans. Transformers, lightning arresters, oil switches and service switches will be required.

Que., Montreal—The Southern Canada Power Co., 20 St. Nicholas St., is having plans prepared for development, construction and equipment to develop 50,000 hp. at Hemming Falls on the St. Francis River. J. C. Smith, c/o owner, Engr.

Sask., Regina—The Regina Municipal Ry. is in the market for a motor to operate d.c. machines now operated by steam. Estimated cost $18,000, including minor improvements.

CONTRACTS AWARDED

Ala., Talladega—The city awarded the contract for the construction of a water supply system to the Merkle Mchy. & Contg. Co., 1733 Walnut St., Kansas City, Mo., $166,000. The city purchases c. i. pipe. Noted May 15.

Kan., Chanute—The city awarded the contract for one 1,000 kw. steam turbine and one 20 kw. exciter to the Westinghouse Electric & Manufacturing Co., Leslie Bldg., Kansas City, Mo. $25,750. Noted May 15.

Kan., Smith Center—The city awarded the contract for gasoline engine driven centrifugal pump and deep well triplex pumps to Terry, Cowan & Smith, 1733 Walnut St., Kansas City, Mo.; motor driven and engine driven centrifugal pumps to the Reeves & Skinner Machinery Co., 1105 Waldheim Bldg., Kansas City, Mo. Noted May 8.

La., New Orleans—The New Orleans Public Service, Inc., A. Patterson, Genl. Supt., awarded the contract for the construction of a 63 x 151 ft. substation on Polymia and Baronne Sts., $300,000; remodeling and extending boiler house on Market and South Peters Sts., $100,000; three oil storage tanks, two on Market and South Peters Sts. and one on Magazine and Pyoras Sts., $50,000 each; remodeling and extending several substations, $50,000, to the Phoenix Utility Co., 71 Broadway, New York, T. L. Holland, Tchoupitoulas and Nuns Sts., New Orleans, Local Mgr.

Md., Baltimore—The Mayor and City Council, City Hall, awarded the contract for two 8,000,000 gal. motor driven centrifugal pumps and electric equipment for the Druid Pumping Sta. to the De Laval Steam Turbine Co., North Clinton St. along tracks of the Pennsylvania R.R., Trenton, N. J. Estimated cost $23,125, compensation method. Noted May 29.

Mass., Boston—The Pilgrim Court Corp., 17 Congress St., will build by day labor a 5 story apartment building, to contain 115 apartments on Riverway. Estimated cost $750,000. Equipment detail not reported.

Mass., North Andover (Lawrence, P. O.)—The M. T. Stevens & Sons Co. awarded the contract for the construction of a steam plant at its mill to M. C. Tuttle Co., 22 Chestnut Terrace, Boston. The turbines will develop 1,700 hp., boiler capacity in excess of this. The power plant will be connected to the mill by a concrete tunnel, also having a large coal storage capacity.

Mo., St. Louis—The Missouri Pacific Railroad, Railway Exchange, awarded the contract for the construction of a track shed and a 34 x 60 ft. boiler room on Van Buren St., to the Folwell Ahlskog Co., 323 North Michigan Ave., Chicago, Ill. Estimated cost $100,000.

Mont., Butte—The Montana Power Co., 40 East Broadway, awarded the contract for furnishing two 7,500 hp. single-runner, single-nozzle impulse turbines, operating under 1,050 ft. head, including auxiliary relief-nozzles and direct-motion governors; also two hydraulic-cylinder operated gate valves at the power house and a butterfly valve at the head of the penstock, latter equipped for electric motor and hand operation, direct and remote control, for the first unit of its Mystic Lake development, to the Pelton Water Wheel Co., 19th and Harrison Sts., San Francisco, Calif.

N. Y., Watertown—The city awarded the contract for the construction of a hydraulic electric plant to the T. F. Breslin Co., Woolworth Bldg., Watertown, $314,316.28. Noted May 15.

Ohio, Cleveland—The Association Bldg. Co., East 93rd St. and Euclid Ave., A. Perkins, Secy., awarded the contract for the construction of a 6 story, 50 x 164 ft. hospital to the Lundoff-Bicknell Co., 5716 Euclid Ave., Cleveland. Estimated cost $400,000. The architect will purchase steam heating system. Noted May 29.

Ore., Milton—The Pacific Power & Light Co., Gasco Bldg., Portland, awarded the contract for the reconstruction of the No. 4 turbine, including installation of Pelton rubber seal rings and high-efficiency runner, at its Walla Walla River plant, near here, to the Pelton Water Wheel Co., 19th and Harrison Sts., San Francisco, Calif.

Pa., Pitcairn—The Pennsylvania System, Central Region, Broad St. Sta., Phila., awarded the contract for the construction of a 1 story, 42 x 90 ft. boiler, machine and transformer shop, here, to the W. Sutherland Constr. Co., Compton Bldg., St. Louis, Mo.

Wis., Milwaukee—The Pittsburgh Plate Glass Co., 213 Lake St., awarded the contract for a 175 ft. stack to the General Concrete Constr. Co., 431 South Dearborn St., Chicago, Ill., turbines to the Allis Chalmers Mfg. Co., West Allis. Noted Feb. 27.

Ont., Niagara Falls—The Canadian Niagara Power Co. will build by day labor, a 26 x 150 ft. transformer station. Estimated cost $150,000. Complete transformer station equipment will be required.

Ont., Owen Sound—The Imperial Oil Co., Ltd., Imperial Oil Bldg., Toronto, awarded the contract for the construction of an oil storage plant, including tanks, pumps, pump house and office, to Schultz Bros., Brantford, $70,000.

Ont., Toronto—The Toronto Transportation Comn., 35 Yonge St., H. H. Couzens, Mgr., awarded the general contract for the construction of a 1 story, 135 x 285 ft. car barn and repair shops, also a 2 story, 42 x 118 ft. office building on Roncesvalles and Queen Sts., to Sullivan & Fried, 81 Victoria St., about $300,000. Total estimated cost $750,000. Heating, plumbing and wiring contracts have not been awarded.

Quebec—The Northern Canada Power Co., Timmins, Ont., awarded the general contract for dam, power house, excavation, concrete work, etc., of the hydro-electric power development on the Quinze River at Ka-Ka-Ke Rapids, to Morrow & Beatty, Peterboro, Ont., on unit basis. Estimated cost $3,000,000. Also having surveys made by Sutcliffe & Neeland, Engrs., New Liskeard, Ont., and G. Summers, for a 90 mi. power line. Noted May 15.